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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
OGDEN UTAH

ANNUAL REPORT

1953

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

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DIRECTOR

(AGRICULTURE - OGDEN)

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EXPERIMENT STATION

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THE OLD AND NEW INTERMOUNTAIN STATION

During 1953 a significant page was written in the 41-year long history of the Intermountain Forest and Range Experiment Station. Part of the record for the last year was a host of current accomplishments toward solving the wild-land problems of the Intermountain region. Among these were sixteen new publications which swelled the total number of reports published by the Station since 1912 to nearly 460. In addition, much new information was obtained about the functioning of watersheds, about forest management, range management, and forest economics, the details of which are given in other sections of this report. The other part of the record for last year was a far-reaching change in the organization of the Station.

Toward the close of the year upon recommendation of the Chief of the Forest Service and approval by the Secretary of Agriculture, the Northern Rocky Mountain Forest and Range Experiment Station was consolidated with the Intermountain Station. This consolidation was made after analyses of each Station showed that combining the two would reduce administrative costs and increase the amount of actual research work on the wild-land problems in the two Station areas.

The territory now embraced by the new Intermountain Forest and Range Experiment Station includes all of Montana, Idaho, Nevada, and Utah and parts of northwestern South Dakota, western Wyoming, eastern California, and eastern Washington. Approximately 84 percent of the area is forest and range land. These wild lands not only contain a rich store of timber, forage, wildlife, and scenic values but they also supply much of the water for the Columbia, Missouri, and Colorado Rivers and virtually all of the water that drains into the Great Basin.

Concurrently with the consolidation of the two Stations, the Secretary's reorganization of the Department brought to the Station two new research responsibilities. One is the program of forest insect studies, surveys of insect infestations, and technical aid to insect control programs formerly carried out by the Bureau of Entomology and Plant Quarantine. The other is a similar program of study, survey, and technical aid to action programs in the field of forest diseases formerly carried out by the Division of Forest Pathology in the Bureau of Plant Industry, Soils, and Agricultural Engineering. Both of these programs will continue as in the past to keep the wild lands within the Station territory as free as possible from damage by forest insects and disease.

Two phases of the range research program of the Station were transferred to the Agricultural Research Service as part of the Secretary's Departmental reorganization. These included research on range reseeding and control of undesirable species, exclusive of the range management aspects of these two types of range improvement studies. Research on range reseeding and control of undesirable species is expected to continue under the Field Crops Research Branch of ARS with which the Station will cooperate closely. Because of this transfer, the Range Research section of this report is devoted almost entirely to an account of the development and progress of artificial reseeding and plant control research from its early beginnings in the region as well as a summary of findings that were made last year.

The organizational changes that were made last year brought an end to one era and marked the beginning of a new one for the Intermountain Forest and Range Experiment Station. The first era began in 1911 when Robert R. V. Reynolds reported upon his examination of seriously damaged range-watershed lands in central Utah. In the following year the first range and watershed experimental studies were organized at what is now the Great Basin Research Center. Shortly thereafter, studies of reforestation were begun in the same locality and in other parts of Utah and southern Idaho. Some 20 years later research in forest management, range management, and watershed management was extended into Nevada, southern Idaho, and western Wyoming, and with that expansion came the appropriate name: Intermountain Forest and Range Experiment Station. Other responsibilities were added to the Station during the 1930's including research on economic problems, flood control surveys, and in 1946 studies of big game-range livestock relations were formalized.

The new Intermountain Forest and Range Experiment Station in 1954 will have a well balanced staff for carrying out research on the wildland problems of the enlarged Station territory. In addition to having competent staffs of entomologists and plant pathologists, the merging of the two stations will strengthen the Divisions of Forest Management, Range Management, Watershed Management, and Forest Economics. The latter division will not only continue studies on resource economic problems, but will also be responsible for extending the nationwide Forest Survey to all of the forest lands in the new Station territory. In addition, the new Station will carry out regionwide research in Fire Control and in Forest Products Utilization Services. Most of the research, as in the past, will be conducted in the field at Research Centers and at Experimental Forests, Ranges, and Watersheds.

WATERSHED MANAGEMENT RESEARCH

Research on the watershed problems of the Intermountain region moved forward on four related fronts during the past year. One phase of this effort brought encouraging results in the search for ways to restore control of summer storm runoff and erosion on damaged range watershed lands. Other studies yielded substantiating information about the amount of plant and litter cover that is necessary for maintaining soil stability and fertility on watershed slopes that are subject to grazing disturbance. Studies of soil moisture also yielded new clues to the problem of minimizing evapo-transpiration losses on water yielding rangelands. On a fourth front, studies were commenced on methods of lessening erosion during and following timber cutting and logging in the commercially important ponderosa pine forests of south Idaho.

QUICK RESTORATION OF DAMAGED RANGE WATERSHEDS

The long standing problem of how to hasten control of accelerated erosion and dangerous storm runoff on damaged high elevation summer range watersheds now appears to be close to solution. This encouraging outlook is based upon records of runoff and sediment production from the Area A and B experimental watersheds at the Great Basin Research Center during the past year in relation to their behavior in previous years.

These two 10-acre areas form a part of the extreme headwater lands of Ephraim Creek. This high gradient stream is one of many which drain the western and the eastern slopes of the high plateaus of south-central Utah. Like virtually all of the streams in that part of the region, Ephraim Creek has produced several violent, debris-laden summer storm floods which originated largely on headwater lands similar to Areas A and B where the plant cover had been seriously depleted by overgrazing of livestock. These floods in Ephraim Creek and elsewhere deeply ripped the stream channels so that every year during the period of snow-fed spring runoff, large additional quantities of sediment are carried into irrigation canals and reservoirs, hydroelectric plants, and other water facilities downstream.

The Area A and B experimental watersheds are typical of much of the high summer range of the Intermountain region in two other important respects. The plant cover is a mixture of low-growing succulent forbs and grasses which can be drastically thinned by persistent overgrazing. The areas are also subject to short duration but high-intensity summer rains that can erode the soil and cause large discharges of overland flow, especially when the plant and litter cover is diminished substantially below normal.

The A and B areas differ from some of the region's high elevation summer range in having a heavy clay soil derived from limestone and a substratum of shale. The surface soil erodes readily and does not take in water as rapidly as do lighter and looser soils elsewhere. The presence of a relatively impervious shale substratum also slows the drainage of free water through the watershed mantle, and encourages quick lateral seepage when the soil is cut by gullies. Because of these soil mantle characteristics, the A and B areas represent probably the most difficult summer range watershed situations in the region for testing runoff and erosion control methods.

Until last year, the Area A and B experimental watersheds had contributed two major facts about the effects of low-growing herbaceous vegetation on soil stability and control of storm runoff. The first of these facts is that soil erosion and storm runoff steps up rapidly as the plant and litter cover is diminished, the breaking point being when more than about one-third of the surface soil is exposed. The second fact is that accelerated erosion and abnormal discharges of overland flow during torrential summer rains can be very substantially reduced by allowing depleted areas to become recovered by processes of natural revegetation, but the rate of recovery is very slow on drastically depleted and severely eroded lands.

The first of these facts is borne out by the contrasting behavior of the two areas over the years 1916 to 1952 when the amount of plant cover on each was varied by different grazing treatments. In the early years of the study when Area A was in a seriously depleted condition and Area B was only moderately depleted, Area A produced about 4.5 times more storm runoff and sediment than Area B. In more recent years after the plant cover on Area B had been drastically reduced by overgrazing and that on Area A had thickened to a 50-percent covering as a result of protection from grazing, Area B produced 6 times more storm runoff and 10 times more sediment than Area A. A reversal of plant cover conditions thus reversed the capacity of the range to control water.

The second fact, that of the positive but slow rate of control that can be achieved by natural revegetation, is demonstrated most clearly by the behavior of Area A. When this area had a plant cover of only about 16 percent, it yielded the equivalent of 2.0 acre feet of sediment per square mile of watershed area per year, most of which was eroded during the summer storm season. This is about three times the rate at which sediment is pouring into Lake Mead from lands in the upper Colorado River Basin. In recent years, with about 50 percent of the soil covered by vegetation and litter, Area A has been eroding at the rate of 0.06 a.f./sq. mi./yr. Thus, a 3-fold increase in plant cover has reduced erosion to about one-thirtieth of the accelerated rate, though it has required some 35 years of protection from grazing to accomplish that degree of control. Still more effective control of storm runoff and erosion is expected on this area as more of the exposed soil is covered by plants but because of the low fertility of the remaining bare areas, the recovery rate no doubt will continue to be very slow.

Late in the fall of 1952 the purposely and drastically depleted Area B was plowed. A few contour trenches were constructed across the most deeply gullied portions and the entire area was then seeded to a mixture of perennial grasses. This was essentially the same treatment that has proved to be successful in controlling summer storm runoff on the Davis County Experimental Watershed in northern Utah where the soils are deeper and have a naturally higher infiltration capacity.

The treatment on Area B very effectively reduced the amount of soil washed from the watershed by the 1953 spring snowmelt. During the spring of 1952 sediment production from Areas A and B was 4.1 and 39.2 cubic feet per acre, respectively, or an A-B ratio of almost 1 to 10. During the spring of 1953, 3.8 cubic feet per acre of sediment was eroded from Area A, or about the same amount as in the previous year, whereas only 0.3 cubic foot per acre was eroded from Area B. Area A thus outproduced Area B on a scale of 11 to 1 and the yield from Area B was less than 1 percent of its production in 1952 before treatment.

After the 1953 spring snowmelt there was excellent initial establishment of the seeded grasses. Above normal rainfall in July not only fostered further growth of the grasses but also provided a further test of the effects of the treatment on control of erosion during the torrential storms.

Four of the July storms caused more runoff and eroded more soil from Area A than in any entire summer since 1937, though soil losses were much greater during similar storms in earlier years when the area was in a more depleted condition. Only one of the 1953 July storms eroded a measureable quantity of soil from Area B (table 1). For all four storms the volume of soil loss per acre was nine times greater from Area A than Area B.

Table 1.--Sediment production from Areas A and B during four runoff producing rains in July, 1953.

Storm date	Rainfall				Sediment production	
	Depth (In.)		Max. 5-min. rate (In./hr.)		(Cubic ft./a.)	
	A	B	A	B	A	B
7/10	0.67	0.65	2.04	1.80	6.4	0
7/28	0.51	0.72	1.80	1.56	12.3	Tr.
7/30	0.91	1.34	2.28	2.52	30.2	5.8
7/31	0.60	0.58	1.20	0.96	5.8	Tr.

The almost complete control of erosion during the spring snowmelt and the unusually heavy July rains on Area B in the first year after its intensive treatment is comparable to the high degree of control that was achieved on the Davis County Experimental Watershed. It is planned to continue to measure the effectiveness of the reseeding and trenching treatment on Area B for a few more years to determine whether the treatment holds up under the impact of more intensive storms and the stress of water from melting snow. If the treatment continues to be as effective as it was during 1953 it should be a useful method for speeding the control of storm runoff and erosion on most of the damaged summer range watershed lands of the region.

RANGE-WATERSHED MAINTENANCE REQUIREMENTS

The role that vegetation and litter plays in controlling water and soil stability has been clearly established by numerous experiments in virtually all parts of the world. There continues to be a lack of useful information, however, regarding the minimum amount of ground cover that is necessary for maintaining a safe degree of control over storm runoff and soil erosion. This lack of adequately tested watershed protection criteria is especially serious in the Intermountain region. Here, all but a small portion of both the forest and rangelands are grazed by livestock or big game each year, a use which not only thins the canopy of vegetation and thus leaves more soil surface open to the direct impact of dashing raindrops, but also leaves the soil in a more compact condition and less capable of absorbing water.

Studies to determine the minimum ground cover requirements for watershed protection purposes thus far have been limited to three of the numerous kinds of rangelands in the region. One already mentioned, is the subalpine herbaceous summer range having a heavy clay soil. Another is the steeply sloping, foothill spring-fall range of south-central Idaho where mixtures of perennial wheatgrass and annual cheatgrass occur on an especially loose and coarse-grained soil derived from granite. The third is the mixed aspen, brush, and herbaceous summer range that occurs on parts of the high Wasatch Mountains in Utah having a deep and loamy soil derived from ancient granites, gneisses, and schists. Not withstanding substantial differences in both the plant cover and soil characteristics of these three range-watershed situations, studies to date have indicated that about two-thirds of the ground surface must be kept covered by plants and litter in order to maintain a satisfactory degree of soil stability and control of overland storm runoff during torrential rains.

Aspen-Brush-Herbaceous Range Requirements

Additional and substantiating evidence of the importance of maintaining an adequate plant and litter cover was obtained last year from a continuation of records from runoff plots in the aspen, brush, and herbaceous range on the Davis County Experimental Watershed. When these plots were first established in 1936 some were very sparsely covered and others well covered. Since then, the plant and litter cover from some has been removed and kept off by burning. Some plots were mulched and seeded to thicken the plant cover and on others the plant cover has been allowed to vary by natural processes of succession. This procedure has made it possible to obtain records of runoff and erosion under a wide variety of ground cover conditions ranging from bare soil to almost 100 percent plant and litter cover.

During the 17-year period 1936 to 1953 there have been nearly 200 summer rains of which 50 caused some runoff on one or more of the plots. Half of these potent storms were of minor intensity, the maximum rainfall rate for 5 minutes being less than 1.5 inches per hour. Nineteen of the storms, or about one per season, were of moderate intensity with maximum 5-minute rates ranging between 1.5 and 3.00 inches per hour. Six of the storms or an average of one every 3 years were of major intensity with rainfall rates ranging from 3.00 up to 6.80 inches per hour for 5 minutes.

No soil erosion occurred during the minor storms on plots which had more than a 35-percent ground cover of plants and litter. With lesser amounts of ground cover, these minor storms caused some soil loss on the average of 1.5 times a year. Moderate storms, which occurred on the average of once a year caused no measurable soil loss on areas which had more than a 55-percent ground cover but caused substantial amounts of erosion with lesser vegetation and litter. A ground cover of 65 percent or more was effective in preventing erosion during the major storms (table 2).

The amounts of storm runoff and eroded soil that occurred on these plots is probably conservative because none of the areas have been disturbed by grazing during the course of the study. The records, however, leave no doubt about the tendency for erosion to increase at accelerated rates as plant and litter cover diminishes. The records also show that under depleted conditions about as much soil is eroded over a period of years by minor and moderate storms as is caused in the same period by the less frequent major storm. The goal of management obviously should be to maintain enough of a plant and litter cover on the ground so as to prevent practically all overland runoff and erosion during the major storm and thus insure control during the more frequent storms of less intensity. This goal for the aspen-brush-herbaceous range in northern Utah appears to be a minimum of 65-percent ground cover.

Maintenance of Range Fertility

The search for ways to restore an adequate plant cover for stabilizing the loose granitic soil on depleted spring-fall ranges

Table 2.--Average amounts of overland flow and soil eroded per storm by various intensity classes of summer rains in relation to amount of plant and litter cover, based on records from 16 Parrish Runoff Plots, Davis County Experimental Watershed, 1936-53

Plant and litter ground cover	Storm intensity classes					
	Minor		Moderate		Major	
	Max. rainfall rates for 5 minutes					
	1.5"/hr. or less		1.5" to 3.00"/hr.		3.0" to 6.8"/hr.	
	Number of effective storms in study period					
	25		19		6	
	Runoff	Erosion	Runoff	Erosion	Runoff	Erosion
Percent	(In.)	(Cu.ft./A.)	(In.)	(Cu.ft./A.)	(In.)	(Cu.ft./A.)
0	0.22	22	0.30	90	0.55	200
5	.03	4	.24	69	.48	172
15	.02	3	.17	38	.40	123
25	.02	2	.12	16	.32	79
35	.01	1	.08	5	.26	44
45			.05	2	.20	22
55			.03	1	.14	6
65			.02	0	.10	1
75			.01	0	.07	0
85					.05	0
95					.03	0

in south-central Idaho has thus far met with little success. Unfavorable soil moisture for the establishment of seedlings is known to be one of the factors that is holding up revegetation by both natural processes and artificial reseeding. High fertility losses, especially losses of total nitrogen, may also be an important factor in keeping the range in a depleted condition, as is indicated from results of a study recently made of these losses.

The amount of total nitrogen in the surface inch of soil was determined on a series of cheatgrass range plots on which the grass and litter cover ranged from 30 to 90 percent. Half of the plots were heavily trampled to simulate the soil disturbance that is caused by heavy grazing. Paired plots were not trampled. All plots were subjected to an infiltrometer rainfall application of 1.8 inches in 30 minutes during which overland flow and eroded soil were measured. The plots were again sampled for nitrogen content from which estimates were made of the nitrogen losses.

The tests on untrampled range showed that from 10 to 13 percent of the available nitrogen supply was lost during the single "storm" on sites where there was less than 70-percent ground cover. With more complete ground cover conditions the losses were on the order of 1 to 7 percent. Heavy trampling disturbance tripled the nitrogen losses on severely depleted sites and doubled the losses even on sites where there was enough cover to minimize overland flow and erosion (table 3).

The significance of these nitrogen losses is not fully understood. For one thing, it is not known how fast nitrogen is replaced in these particular range soils. It is not known either how critical nitrogen is in relation to other nutrient elements in these soils. However, the large nitrogen losses which were associated with even larger soil losses that occurred on the trampled range plots suggests that soil disturbance will have to be kept to a minimum if revegetation and improved soil stability are to be achieved on the granitic soil ranges of south Idaho.

Table 3.--Estimated values of total nitrogen loss, soil erosion, and overland flow per simulated major summer rain on cheatgrass-granitic soil range in south-central Idaho

Ground cover	Overland flow	Soil erosion	Total nitrogen loss	
			Amount	Supply
(Percent)	(Percent)	(lbs./A.)	(lbs./A.)	(Percent)
		NO SOIL TRAMPLING		
30	17.8	1,375	8	11.0
40	12.0	1,220	8	10.5
50	8.2	965	9	11.1
60	6.5	830	12	13.4
70	5.4	625	13	12.7
80	4.1	420	8	6.7
90	3.2	260	1	0.7
		HEAVY SOIL TRAMPLING		
30	39.2	2,420	23	30.7
40	26.5	2,210	21	25.1
50	17.6	1,740	20	21.3
60	13.4	1,530	20	18.3
70	11.2	1,280	19	15.0
80	8.2	710	19	12.8
90	6.3	460	19	11.2

MINIMIZING EVAPO-TRANSPIRATION LOSSES

For the Intermountain region as a whole only about 10 percent of the rain and snow that falls on the land becomes available as usable water in streams and ground water basins during the average year. The other 90 percent of the annual precipitation is returned to the atmosphere by evaporation from the land and by the transpiration of plants. When it is considered that the amount of water in this region is only about 25 percent of the supply over the United States as a whole, any reduction that can be made in the evapo-transpiration losses which would result in increased yields of usable runoff, would be of great value.

Making more water available for useful runoff by reducing evapo-transpiration losses, however, is not a simple problem. In the first place, enough plant cover must be kept on watershed slopes to maintain soil stability and prevent destructive floods. Moreover, with only 4 percent of the land area capable of producing farm crops, the economy of the region demands the greatest possible timber and forage production on the other 96 percent of the area. To meet these two requirements for good wild-land management and at the same time bring about a reduction in evapo-transpiration losses, leaves only one solution. That is to find the kind of plants which are most efficient in their use of water.

An exploratory study of the amount of water consumed and the amount of forage produced during one growing season by four kinds of range cover was completed last year at the Great Basin Research Center. In this test, areas which had been planted to smooth bromegrass consumed the most water but produced the most forage and made the most efficient use of the water consumed. By comparison, areas with a timothy grass cover consumed 0.79 inch less water and produced less than half as much forage. Kentucky bluegrass areas consumed about 1.0 inch less water than the timothy areas but were more efficient in the use of that water. Areas having a mixture of dandelion and sweetsage, typical of depleted summer range in that locality, consumed the least water but were also by far the least efficient producer of forage per unit of water consumed, (table 4).

The variability in the water consuming efficiency of these four types of plant cover suggest the possibility of achieving different objectives on range-watershed lands. Where maximum forage production is desired, management should strive to establish grasses comparable to smooth brome. This grass develops not only a shallow, rhizomatous root system, but also extensive fibrous roots which occupy the soil to depths of 5 to 6 feet, which result in virtually complete extraction of all available soil moisture by the end of the growing season. Where water yields are more important than forage production, a sod-forming type of cover with less deep roots, as is typical of Kentucky bluegrass stands, appear to be the most desirable. Under such conditions, less water from melting snow will be required to recharge the mantle and more of the winter precipitation will therefore be available for streamflow. Thin stands of taprooted weeds appear to have no place in range-watershed management because of their inefficiency for producing forage, for keeping soil stable, and for preventing potentially destructive floods.

Table 4.--Summer season evapo-transpiration losses, forage production, and differences in amounts of water available for streamflow under four range plant cover conditions on high elevation summer range, Great Basin Research Center

Range cover	Evapotranspiration loss	Water available for streamflow	Forage production	
			Total	Unit
	(Inches)	(Inches)	(lbs./A.)	(lbs./A. /in. water)
Smooth brome	11.33	0.00	3,220	350
Timothy	10.54	.79	1,440	135
Kentucky bluegrass	9.47	1.89	1,980	210
Dandelion-sweetsage	8.96	2.37	715	80

Additional evapo-transpiration studies are planned for the coming year. These will include tests with a greater variety of range types as well as a study of the effects of different seasons of clipping.

EROSION CONTROL STUDIES STARTED ON FOREST LANDS

How to maintain the stability of the soil mantle on steeply sloping forest lands in south-central Idaho has become a problem of great concern. Until recent years most of the timber cutting and logging in the commercially important ponderosa pine forest has been on the most gentle and readily accessible slopes. Cutting operations are now reaching into more remote areas having very steep slopes. Serious erosion has already occurred on many of the cutover and logged areas and no tested criteria are available for guiding future operations. To cope with this situation two studies of methods for controlling erosion were started last year.

One study was set up in the Boise Basin Experimental Forest in conjunction with a forest management study. The latter will involve logging of separate subdrainages with large and small tractors and cutting of timber to high and low reserve volumes. To test the effects of these cutting and logging treatments on sediment production, debris basins for trapping and measuring eroded material will be installed on each of 16 logging compartments and on 4 subbasins not scheduled for cutting or logging. During the past year 11 of the 20 debris basins were constructed. The basins behind the dams were gridded and referenced and level controls were established for measuring future sediment deposits. Installation of the remaining 9 debris basins is scheduled for the coming year.

The second study was on an active timber sale area near the Boise Basin Experimental Forest. This study was aimed at determining how to stabilize haul roads and skid trails. Nine sections of haul roads were selected for study. These varied in gradient from 5 to 20 percent. Cross ditches were installed at various intervals on all gradient sectors immediately after logging was finished. In addition, 18 skid trails were selected for study, half of them being down drainage bottoms and half of them on plain slopes. The gradients of the skid trails ranged from 20 to 70 percent. These are to be treated with various types of slash plugs at different intervals during the next season. Level controls will also be established on all of the critical haul road and skid trail sections during the coming year as a basis for measuring cross-sectional changes in subsequent years.

FOREST MANAGEMENT RESEARCH

There were numerous signs of increased interest in the timber resources of the Intermountain region during the past year. Among these was the start of pulpwood operations on the Targhee National Forest, the first pulpwood to be cut in the Intermountain region. The need for more extensive salvage cuttings in overmature stands was made manifest by the seriousness of insect epidemics and the spread of disease largely in, but not confined to, south-central Idaho. The search for more ponderosa pine timber continued with more accurate appraisals being made for stumpage that was sold. Alert loggers sought and found means of reducing their operating costs to meet the relentless specter of competition. The volume of timber cut on the national forests of the region continued its steady rise. These interesting and progressive signs stress the need and the logic of an even greater research effort which will increase the productivity of Intermountain forests.

Research in forest management moved forward in three related fields during the past year in an effort to find answers to some of the most important problems on the forest lands of the region. The cutting and logging phases of a comprehensive study of ponderosa pine production got under way in the Boise Basin Experimental Forest near Idaho City, Idaho. Important guides for managing lodgepole pine forest stands were developed from a regionwide study of that species. In addition, much of the most valuable timber lands in south-central Idaho were inventoried as part of the nationwide Forest Survey program.

PONDEROSA PINE PRODUCTION STUDY UNDER WAY

The major problem in management of the ponderosa pine forest lands of the region continues to be the difficulty of securing a high net growth per acre and ample regeneration in the residual stand. There are several aspects to this over-all problem. In areas where no seed source exists there must be found a more satisfactory and reliable method of reforestation than is now available. Due to the paucity of the intermediate size classes there must be developed suitable criteria for increasing the development and growth rate of sapling and pole stands if future cutting quotas are to be maintained. Because quality wood must be produced on short rotations, a cheap, efficient method of pruning must be developed and perfected. Satisfactory cutting methods must be contrived to secure maximum production of desirable grades from the extensive, pure, even-aged stands in which commercial cutting has already begun.

Solutions to these several aspects of the ponderosa pine production problem lie in answers to an even larger number of specific questions. Some of these questions are as follows:

a. What severity of cutting is most suitable for stands of different initial volumes?
b. If stands of different initial volumes are cut so as to leave varying volumes of reserve and different silvicultural methods are employed in these cuttings, what will be the rate of growth of these residual stands?
c. Is single tree (stemwise) selection based on insect and disease risk preferable to groups of trees (groupwise) based on age- and size-class distribution as a silvicultural cutting method?
d. When a careful but reasonable compromise to reduce felling damage is used, are felling costs markedly increased?
e. On the steep topography and granitic soils of central Idaho, should logs be extracted by large D-8 tractors or smaller D-4 tractors?
f. Which of these two methods causes more damage to advance reproduction and which results in more soil loss?
g. What is the difference in cost per thousand feet of logs delivered to the landing by these two methods?
h. How soon are openings created by cutting invaded by vegetation and what means must be used to prepare these areas for natural regeneration?
i. What exact method of artificial regeneration promises the best results at least cost?
j. How much planning and effort is involved in learning the age- and size-class distribution of stems in ponderosa pine stands, and in cutting in a way that will improve this distribution?

A ponderosa pine production study on the Boise Basin Experimental Forest has been designed to provide answers to all of the above questions. The Divisions of Forest Insect and Forest Disease Investigations are also cooperating to supplement the forest management data in an effort to trace and determine primary causes of saw-tree mortality.

A good start was made on the installation phase of the ponderosa pine production study during the past year. The first replicate of 8 compartments, embracing 445 acres, was logged. Also, a total of 315 acres of virgin timber was covered by a 100-percent cruise which completed the initial inventory of the 16 minor drainage compartments which comprise the study area. Approximately half of the reproduction plots (randomly located "hubs" with radiating arms) for sampling the prelogging and postlogging distribution of trees of all sizes in compartments to be logged in 1954 was established.

An Administrative Use Agreement (Reg. S25) was drawn up in cooperation with the Boise-Payette Lumber Company to cut and remove the timber according to plan. This plan was not markedly different from the usual commercial national forest sale except for the locating and flagging of spur roads and felling timber at right angles to the contours wherever possible. The operation was administered by an assistant ranger detailed by the Boise National Forest and who was in complete charge of the work. The operation began on September 15 and closed January 16, 1954 with the removal of 2,402,430 board feet of timber which was within 1.4 percent of the estimated amount.

Considerable prelogging preparations were necessary for the 1953 operations, particularly the location of spur haul roads. With the rough topography and erosible character of the soil, it was necessary to exercise all reasonable precautions. In cooperation with the Influences Division of the Station and the operator, roads were planned, explored, and finally flagged after attempting to keep grades as low as topography and timber distribution would allow. The roads were located on side slopes so as to leave a 10-foot strip of undisturbed vegetation between the lower edge of the overspill and drainage bottom. It required about 8 miles of these spur haul roads to service the 16 compartments in the study area. Postlogging treatment of roads and slash was carefully planned to reduce soil movement and fire hazard to a minimum.

A system of cost-keeping was developed by the operator's forester so that felling and skidding costs could be kept separately for each of the three classes of initial stand volume per acre in each compartment. This will permit a detailed analysis of their relationship to different degrees of volume removed from each volume class. This analysis, including a comparison of the D-4 and D-8 tractor performance, should prove of interest and value in view of the current interest expressed by logging operators to use smaller machines.

To insure efficient and certain progress in the technical aspects of the study during logging, several aids were furnished the operator which proved useful and completely successful. The first was a map of the Experimental Forest showing all compartments, the year of logging, and the method of logging for each. A second was a set of individual compartment maps at a scale of 5 chains to the inch showing locations of single marked trees or groups of marked trees. A third was a shirt pocket-sized pamphlet--one for fallers and one for cat-skinners--setting forth and explaining boundary marks, tree marks, permanent and semipermanent stakes, value of reproduction, etc., and emphasizing the need of their cooperation to make the experiment installation a success. These aids were used daily by all concerned in general supervisory work, in planning roads and landings, in cutting and skidding, and in locating randomly selected check-scale trees. Their use is highly recommended in similar experimental activity.

Photographic stations were established before cutting from which black and white and kodachrome exposures were made before cutting started.

Considerable work remains to be done next year to complete the installation phase of this study. Most of this will center on the second replicate of eight compartments which are to be cut and logged in 1954. Timber marking will be completed in four of the risk (stem) selection compartments and in four group selection compartments. Study plot "hubs" and photographic stations will be established on all of the compartments in the second replicate before logging starts. Suitable post-logging treatments will be made and analyses will be started on stand structure and logging costs for the study as a whole.

PROGRESS ON LODGEPOLE PINE STUDIES

The second year of study on the lodgepole pine situation in the region brought the problems of that type into sharper focus. These efforts also made it possible to refine criteria for classifying lodgepole pine stands and to evaluate the necessity for doing post-logging stand improvement. New information was also obtained about regeneration.

Regionwide analysis of the lodgepole pine forests revealed two problems to be most urgently in need of solution. One of these is to determine how to harvest even-aged and uneven-aged mature and overmature stands of pure lodgepole and lodgepole in mixture with spruce and fir as a means of increasing net growth per acre, obtaining satisfactory restocking of desired species, and eliminating or at least minimizing mistletoe infection. The second problem is how to make intermediate cuttings in immature and young stands that will stimulate growth of stagnating stands and eliminate or at least minimize mistletoe infection and otherwise improve stand health.

These two problems are intimately related to the utilization of lodgepole pine. For years the market demand for products has dictated the plan of cutting in most stands and the silvical requirements of the species within them have received little attention. Stands of similar age, structure, and composition in different locations are still marked for cutting under different rules. At the same time, stands of dissimilar age, structure, and composition in the same area are generally cut for the same products. Obviously, this makes difficult the regulation of growing stock on each forest.

Reliable criteria for recognizing the different stands must be formulated and practical methods for cutting and utilizing these stands in relation to their silvical requirements must be developed. Since regeneration can be derived from seed stored in cones on the slash, a practical method of slash disposal must be developed, especially in heavily cut areas. Additional investigation to obtain a better understanding of the relationship between slash, fire, cone-opening, and seed viability is needed. If cutover areas are to be restocked to a desirable density with seedlings free from mistletoe infection a suitable method of controlling this ubiquitous parasite must be found.

Stand Classification

As an initial step in gauging the over-all problem of cutting in the lodgepole type, general observations on the occurrence, structure, and composition of stands were made in 1952. These observations led to the preparation of a preliminary stand classification for this species.

In 1953 a survey of representative stands was initiated on the Ashley, Bridger, Targhee, and Wasatch National Forests. This survey was designed to perfect recognition criteria for each stand included in the preliminary classification. It was also designed to provide data for stand and stock tables and data on growth rates of both trees and entire stands.

The first phase of this survey was confined to mature and overmature stands because they provide the greatest volume of annual cut. The information collected will help forest managers recognize the various stands which exist on their respective forests, will aid them in estimating growing stock and will guide their decisions in prescribing necessary cultural practices.

The preliminary classification of stands presented in the problem analysis was revised and the characteristics used for recognizing each stand were redescribed and strengthened.

Observations to date indicate that the stands most commonly cut on each of the four forests examined fall into the following classes:

Ashley

pure, even-aged, overmature
pure, uneven-aged, overmature
mixed, uneven-aged, overmature (lodgepole pine and Engelmann spruce)

Bridger

pure, even-aged overmature
pure, uneven-aged overmature
mixed, uneven-aged, overmature (lodgepole pine, alpine fir, and Engelmann spruce)

Targhee

pure, even-aged, immature
pure, two-aged, overmature

Wasatch

mixed, uneven-aged, overmature (lodgepole pine, alpine fir, and Engelmann spruce)

Analyses of plot data revealed a striking uniformity in both numbers of trees and basal areas between stands classified similarly on each forest through purely observational means, which indicates that the recognition criteria are sound.

Other findings from the stand classification study revealed that:

1. Mixed stands generally have more basal area than pure stands of equal age.
2. Pure, even-aged, overmature, and pure, uneven-aged, overmature stands on the Bridger Forest have nearly equal basal area.
3. Mixed, mature and overmature stands on the Wasatch Forest show more irregularity in stocking and stand structure than stands of similar age on the other forests.

Post-Logging Stand Improvement

Observations were made and temporary plots were taken in cutover stands to determine the effect of past cuttings on present stand condition. This study was designed to aid in estimating the stand improvement work necessary for leaving future cutover areas in a productive condition. Data taken included the number and kind of trees left on areas cut 1 to 3 and 7 to 10 years ago, and the prevalence of mistletoe, *Cronartium* rusts and *Fomes pini* in each stand.

Difficulty was experienced in identifying mistletoe, rusts, and *Fomes pini* on standing trees when there was little external evidence of infection, but there appears to be little relationship between age since cutting and the incidence of either of these agents in stands cut up to 10 years ago. Mistletoe was found to occur more frequently than either of the other two pathogens. *Fomes pini* was observed to be the principal cause of decay, thus corroborating evidence from studies made outside the region. Although the rusts are of widespread occurrence, concentrations were found to be restricted to relatively small areas. The pathological importance of rusts from a regionwide standpoint, therefore, appears to be less than originally assumed.

Regeneration

Ground cover and reproduction were sampled on 6-year-old clean-cut areas. In addition, cones were collected from standing trees and from slash. These efforts were made to determine the kind and distribution of ground cover present, reveal where reproduction is becoming established, measure the amount of reproduction established, and determine the viability of seed of various ages and from different positions in 6-year-old slash.

On clean-cut areas ground cover and stocking were found to be distributed as shown in table 1. Areas covered by slash occurred on 56.6 percent of the total area sampled and contributed to 53.0 percent of total stocking. Most of the slash, as shown, was under 1 foot deep. The degree to which stocking is affected by depth of slash has not been determined but the data indicate that a correlation exists. Ground cover other than slash was primarily disturbed duff and disturbed mineral soil. These disturbed areas, as expected, are more effective seedbeds than the undisturbed.

Table 1.--Distribution of ground cover and stocking of lodgepole pine on 6-year-old clean-cut areas 1/

Ground cover class	Percent of area covered		Percent of total stocking	
	Slash	Other	Slash	Other
Slash under 6 in. deep	26.7		34.4	
Disturbed duff		22.9		29.4
Slash 6.1 in. to 1.0 ft. deep	15.3		13.5	
Disturbed mineral soil		11.4		13.7
Slash 1.1 ft. to 2.0 ft. deep	9.8		4.1	
Undisturbed duff		6.1		3.1
Brush and grass		3.0		0.8
Slash 2.1 ft. to 3.0 ft. deep	2.4		0.2	
Slash 3.1 ft. and over deep	2.4		0.8	
Undisturbed soil		0.0		0.0
Subtotal	56.6	43.4	53.0	47.0
Total	100.0		100.0	

1/ Only 4.9 percent of stocking is alpine fir and Engelmann spruce.

The lodgepole pine studies to date have provided information for several reports which are to be developed in 1954. The reports will cover (a) regional problems and research needs, (b) stand classification, (c) progress on methods of improving cutover stands, (d) occurrence and distribution of reproduction on clean-cut areas, (e) viability of lodgepole pine seed, and (f) pulpwood cutting methods and equipment.

FOREST SURVEY

Desirable forest management planning, particularly the regulatory phase, cannot proceed efficiently until full knowledge of inventory is available. The species and volume of each must be known to the forest manager before he can proceed to utilize the timber resource to its fullest extent. Those charged with the responsibility of managing the forests of the region have been seriously handicapped until recent years by a lack of useful timber resource data.

A start in remedying this situation was made in 1949 when the Southwest Idaho Timber Survey was launched. It was designed to reveal the volume and location of operable timber available on the watersheds of the Boise and Payette Rivers and on parts of the Salmon and Snake River drainages. This survey is being extended to cover all of the commercial forest lands in the Intermountain region as part of nationwide Forest Survey.

During the past year field inventories were completed on some 2 million acres of forest land in southwestern Idaho. This completed the field work for the Southwest Idaho Timber Management Study. Office compilation of field data collected on this project in the years 1951 and 1952 was also nearly completed in 1953. In addition, Forest Survey crews completed field inventory of approximately 300,000 acres of forest land on the Challis and Sawtooth National Forests and adjacent lands.

During 1953 Forest Survey personnel assembled regional data on the amount of timber cut and wood utilized for inclusion in the nationwide Timber Resource Review. A study of logging residues was also made as part of an effort to reduce logging waste.

A paper, "Wood Residues as Soil Amendments," was presented at the annual meeting of the Western Soil Research Committee, December 9-11, at Logan, Utah. Beginning in 1954 the headquarters for the Forest Survey will be at Ogden, Utah and will function under the Division of Forest Economics.

RANGE MANAGEMENT RESEARCH

Range research at the Intermountain Station is now undergoing organizational changes. On the one hand, the scope of range research is being reduced by the transfer of most of the work in artificial revegetation and noxious plant control to the Agricultural Research Service. On the other hand, the areal extent of the Station's program of range management research is being enlarged by consolidation with the Northern Rocky Mountain Station.

Research on artificial range revegetation and control of noxious plants has been one of the major efforts of the Intermountain Station since the beginning of wild-land research shortly after the turn of the century. This phase of the Station's research program has made many important contributions. With the transfer of this program to ARS, it seems appropriate to review the progress that has been made in this field from the early beginnings of research as well as to report the findings of last year.

EARLY RANGE REVEGETATION STUDIES

At the time the forest reserves (now national forests) were established, erosion, floods, and depleted plant cover called attention to the need for artificial seeding. It was recognized that trees could be planted to make good the ravages of wasteful timber cutting and fire. If this were possible, could not shrubs and grasses also be planted to protect damaged high-mountain watersheds? Presumably species like Kentucky bluegrass, timothy, and white dutch clover, introduced in hay for draft animals, had already become established in moist spots along roads and logging trails. Whether or not the idea originated from seeing them already established, it is notable that the earliest seeding trials utilized these and other pasture species of humid regions.

The first early trials, undertaken over a wide range of conditions and sites between 1907 and 1911, were mostly failures either because the species used were not adapted or because methods of planting were faulty. The principle was not fully recognized that, for plants to be successful, they must come from habitats similar to those in which they are being seeded. There were some successful seedings, including Kentucky bluegrass and smooth brome, but their success was not manifest during this early period.

With the establishment of what is now the Great Basin Branch Station near Ephraim, Utah, in 1912, experimental plantings with several species were made, mostly in the aspen and subalpine zones. Several of these plantings were outstandingly successful, particularly those of smooth brome. Considerable success was also achieved with mountain brome, slender wheatgrass, timothy, Kentucky bluegrass, and orchardgrass, and some success with transplants of wild currant.

Between 1925 and 1933 seeding trials in central Utah were also carried out on moderately sloping openings in the oakbrush zone. Strains of sweetclover were tested in cooperation with the Bureau of Plant Industry, and experimental plantings were continued with grasses. Emphasis on use of sweetclover reflected widespread initial success with sweetclover on the Plains. These trials also compared spring with fall plantings, opening sagebrush with the moldboard plow in contrast with no disturbance, and covering the seed by brush dragging and by trampling of sheep as compared with no covering. No difference was noted between spring and fall plantings, but opening the sagebrush and brush dragging gave better initial stands than no disturbance or trampling with sheep. In the oakbrush zone smooth brome, crested wheatgrass, mountain brome, and slender wheatgrass proved particularly successful.

The results of these and other early studies were summarized in three Departmental publications: Forsling, C. L., and W. A. Dayton. Artificial reseeding on western mountain range lands. U. S. Dept. Agr. Cir. 178, 1931; Price, Raymond. Artificial reseeding on oakbrush range in central Utah. U. S. Dept. Agr. Cir. 458, 1938; and Stewart, George, R. H. Walker, and Raymond Price. Reseeding range lands of the Intermountain region. U. S. Dept. Agr. Farmers' Bul. 1823, 1939.

These early studies provided an understanding of problems of range rehabilitation which could have been obtained in no other way. Recognition of problems was achieved in other places than central Utah, notably in southern Idaho. The unstable, eroding granitic soils of southwestern Idaho posed a particularly difficult problem in range rehabilitation. The establishment of spring-fall range research in eastern Idaho in 1922 provided an opportunity for observation there of possibilities for range improvement through artificial seeding and control of sagebrush. In various parts of the region an acquaintance was gained with range environments from the sagebrush to the subalpine zones. Special problems such as those posed by competing vegetation came to be recognized. Certain principles were developed, notably the necessity for selectivity in use of species for artificial seeding, necessity for coverage of seed (much seed had been wasted by indiscriminate broadcasting), and the desirability for planting at one time of year in preference to others.

Furthermore these early trials have given rise to an orderly procedure in tackling problems of artificial revegetation. A system of screening and testing large numbers of species was developed. First they were planted in small, weeded plots under optimum conditions; then, by a variety of methods, the survivors were planted in larger plots where they would have to compete with native vegetation; and, finally, the best-adapted species are not intended as planting guides but simply as a rough summary of knowledge.

Table 1.--Principal species adapted to plains, valleys, and foothills

Grasses	Forbs	Shrubs
Crested wheatgrass	Yellow sweetclover**	Bitterbrush
Intermediate wheatgrass	Alfalfa (creeping forms or Ladak)	Fourwing saltbush
Pubescent wheatgrass	Chickpea milkvetch	Winterfat
Tall wheatgrass**	Palmers penstemon (*P. palmeri*)	Blueberry elder*
Siberian wheatgrass	Wasatch penstemon* (*P. cyananthus*)	Oldman wormwood* (*Artemisia abrotanum*)
Western wheatgrass	Cowparsnip*	
Bluebunch wheatgrass	Sweetanise*	
Indian ricegrass	Showy goldeneye*	
Russian wildrye	Belvedere summercypress** (*Kochia scoparia*)	
Giant wildrye	Fivehook bassia** (*B. hyssopifolia*)	
Smooth brome (southern strain)*		
Reed canarygrass*		
Tall fescue**		
Bulbous barley		
Big bluegrass		
Bulbous bluegrass		

* Adapted to moist sites at low elevations or to average sites at higher elevations.

** Adapted to moist sites which may be somewhat saline.

The principal needs in species-adaptability research are as follows:

More species and strains need to be tested. Comparisons that have been made between strains of many grasses and legumes have shown this to be a very important aspect of the problem of finding adapted plants with desirable qualities. In the past much of the seed for testing has been obtained from BPISAE and SCS. Whatever the future sources of seed may be, they should be exploited fully. Strains of natives from different parts of the Intermountain region--for example, mountain brome, Indian ricegrass, and bitterbrush--indicate possibilities of adaptation to a wide variety of sites to take full advantage of particular environmental conditions. Bitterbrush is a notable example. Sprouting and layering forms of bitterbrush in southeastern Idaho and central Utah, if adapted, may have tremendous value in southwestern Idaho, western

Nevada, and eastern California where the native, nonsprouting bitterbrush is eliminated by fire over large areas.

Table 2.--Principal species adapted to mountain rangelands

Grasses	Forbs	Shrubs
Smooth brome (northern and southern strains)	Mountain lupine (*L. alpestris*)	Oldman wormwood
Alpine brome (*B. tomentellus*)	Alsike clover*	Blueberry elder
Meadow brome (*B. erectus*)	Chickpea milkvetch	Squaw currant
Mountain brome	Showy goldeneye	Bitterbrush
Orchardgrass	Cowparsnip*	
Kentucky bluegrass	Sweetanise	
Timothy	Wasatch penstemon	
Tall oatgrass		
Slender wheatgrass		
Bearded wheatgrass		
Quackgrass		
Reed canarygrass*		
Meadow foxtail*		
Blue wildrye		
Creeping red fescue		

* Adapted to moister-than-average sites.

Adapted plants are needed for difficult sites. Such sites include harsh, eroded soils at all elevations, dry, alkaline soils in desert-shrub areas with low rainfall, and unstable soils like those derived from loose granite in southwestern Idaho. Since erosion control is the chief objective, high forage production is not so important as ability to spread vegetatively and to form an effective cover, both of crownspread and litter. The possibilities of vegetative propagation on such sites need to be given more searching trial.

Adapted legumes are needed both to increase the nutritive value of forage and to build up soil nitrogen. The need is particularly great on the drier rangelands.

While considerable progress has been made in some parts of the Intermountain region in planting shrubs for big game range revegetation, much more work needs to be done in testing shrub species.

Stands of shrubs are not obtained so readily as with grasses because of seed dormancy, and these problems need to be more fully investigated. Shrubs may also have an important place on harsh sites for erosion control and for creating a favorable microenvironment for establishment of herbaceous vegetation.

The possibilities and problems in using mixtures with some species serving as nurse crops for others, to take advantage of site variations, to produce a balanced forage, and to adjust to variations in weather and other environmental factors, need to be more fully explored. The advantages of mixtures in obtaining successful stands must be equated against their performance under grazing where differences in palatability and tolerance to cropping often create management problems.

Site Factors

A basic idea that has underlain consideration of site factors in artificial revegetation has been to begin with the more favorable sites and move to the more difficult sites later. Although progress has been very great during the past 20 years, knowledge of what to do about deteriorating sites where soil is rapidly eroding has perforce lagged. The greatest successes on eroding slopes have been achieved with contour trenches or furrows that conserve moisture and stabilize the surface until the seeded plants become established and restore a vegetal cover. Some efforts have been made to improve poor sites and induce seeding success by the use of fertilizers. In some trials the vegetation has shown a good response, but in general response to fertilizers has been either temporary or slight. Some experiments have also been made with artificial mulches and soil conditioners in efforts to improve the microenvironment during the seedling emergence stage on harsh soils, but these have not been very successful.

Another basic idea in the selection of sites is that the residual vegetation indicates the character of the site and gives a good idea of what species to plant. On lands where shadscale and other salt-desert shrubs are characteristic, for example, we know that it is not safe to advocate artificial seeding because these lands are usually too dry. Tall and dense sagebrush commonly indicates a good seeding site, while sparse, low-growing sagebrush is associated with thin soils and indicates likelihood of low production. Saltgrass on moist lowlands, sagebrush on well-drained sites, oak and maple in the lower mountain slopes, aspen overstory and aspen openings in the montane forest zone, and weedy subalpine openings, all call to mind groups of species for artificial seeding that have been tested during the past 20 years and that are known to be particularly well adapted to the environments reflected by the native vegetation.

For several years a study has been under way in southeastern Idaho, northern Nevada, and Utah to relate production of crested wheatgrass to production of native vegetation and to see whether precise indicator values could be established. Results of this study are currently being analyzed. A number of studies have been made of problems of germination and early seedling survival. Publications on these problems include: Plummer, A. Perry. The germination and early seedling development of 12 important range grasses. Amer. Soc. Agron. Jour. 35(1): 19-34, 1943; Frischknecht, Neil C. Seedling emergence and survival of range grasses in central Utah. Agron. Jour. 41(2): 63-65, 1949; Plummer, A. Perry, and Neil C. Frischknecht. Increasing field stands of Indian ricegrass. Agron. Jour. 44(6): 285-289, 1952.

Future research should explore exhaustively the factors responsible for failure of seeding on harsh sites, using those species which have shown most promise to date and giving more emphasis to woody plants. These studies should ascertain the extent to which cultivation, fertilization, mulches, soil conditioners, trenching, etc., ameliorate the microenvironmental conditions responsible for failure. When these factors are understood, and when they can be overcome on an experimental basis, it may be possible to devise practicable procedures for solving the problems of seeding harsh sites on a field scale.

Seeding is sometimes undertaken where it is unnecessary. This is partly attributable to a general lack of knowledge of the potentialities for recovery of many of our native ranges under improved management. The amount of protection needed to permit a seeded stand to become established, if applied to the native stand, would result in many cases in very great improvement at much lower cost. The problem is to know where improvement through management alone will do the job. This involves careful analysis of the residual vegetation. There are abundant opportunities to gain such knowledge in the Intermountain region through ecological measurements of trend on range where management practices have recently changed or are about to be changed.

Methods of Planting

Most early attempts at artificial range revegetation were failures, not only because species used were not adapted to sites in which they were planted but because methods used did not meet the needs of the germinating seed or the young seedling striving to become established. Indiscriminate broadcasting without soil preparation was a common cause of failure and at the same time the necessity for eliminating competition of residual vegetation was not recognized. The trampling of grazing animals was commonly regarded as a sufficient means of "planting" the seed. It was argued that this is "nature's way"--without recognizing that while one successful seed in 10,000 may be enough for nature's purposes it is not enough for man's.

There is no point in bemoaning the mistakes of the past, of estimating how many tons of seed or how many man-years of effort have been thrown to the winds by the uninformed. The serious thing is that in some quarters these mistakes are still being made in spite of the publications of many forest and range and state agricultural experiment stations. Promotional campaigns are being waged today to dispose of vast quantities of seed of species not adapted to rangeland. Even if the species were adapted to western ranges, the methods advocated by the promoters are such as virtually to insure failure. As this is being written we are in receipt of a promotional letter from a seed company advocating broadcasting of seed on arid lands with no other ground preparation or reduction in competition than may be provided by the trampling of cattle. It seems particularly unfortunate that stockmen and others desiring to improve our natural range resources should be made a prey by those who are either unscrupulous or ignorant.

Actually the basic principles involved in methods of successful range seeding are not greatly different from the principles of most successful farming. These include elimination of undesirable vegetation, covering the seed to protect it and the seedling during early stages of growth, and timing planting to take advantage of the most favorable features of the climate.

Seeding techniques

A basic principle in artificial revegetation is to cover the seed. This is essential to supply it with continuous moisture during the period of germination and seedling establishment when an intermittent supply such as would be received on the surface of the soil would serve simply to promote germination and death. Covering also serves to anchor the seedling. The surest means of covering the seed is by drilling, although there are circumstances in which broadcasting is effective. One is during processes of mechanical brush eradication involving considerable soil disturbance. Another is on freshly plowed ground where sloughing and settling of the soil will cover a high proportion of the seed. Still another is in fresh mountain-brush and forest burns which have a considerable volume of ash. Still another situation in which broadcasting is effective is prior to or during leaf fall in aspen or mountain-brush types where the fallen leaves provide the necessary cover. Since much seed is wasted by broadcasting under any of these conditions, considerably more must be applied per unit area than when drilling.

A second principle in artificial revegetation is to cover the seed at optimum depth. This can best be done by drilling. Drilling makes the most efficient use of seed and distributes and covers it uniformly. Care is needed to keep the seed from going deeper than 1/4 to 3/4 of an inch below the surface. Large-seeded species can be planted deeper than small-seeded species. Fresh burns and Russian-thistle stands provide ideally firm seedbeds without the necessity of expensive preparation to remove competing vegetation. (Russian-thistle develops late in spring and doesn't compete with grass seedlings to the extent that earlier annuals do.)

A third principle is close spacing so that the seeded plants can readily suppress weeds and brush seedlings. This means that heavy seeding rates are often an economy in the long run. It is true that many light seedings have thickened to full stands in time, but such eventual success is by no means certain and is achieved at the cost of several years' grazing use. (Hull, A.C., Jr. Depth, season, and row spacing for planting grasses on southern Idaho rangeland. Amer. Soc. Agron. Jour. 40(11): 960-969, 1948; Mueggler, Walter F. and James P. Blaisdell. Effect of seeding rate upon establishment and yield of crested wheatgrass. _MS. in preparation_.)

Reference has been made to failures on thousands of acres of seeded range because of faulty methods of seeding and inadequate elimination of competition. A recent example that has attracted considerable interest is "pellet seeding." Seeds of adapted species were pressed into earthen pellets, sometimes with fertilizer, and these were scattered by airplane. After large sums had been spent to little avail for widespread pellet seeding on western public lands, a study was performed by this Station which showed conclusively that pellet seeding was a mistake. The pellets were ineffective for four reasons. First, the seed was not adequately buried so as to be in contact with a continuing supply of soil moisture; second, competition of native vegetation was not reduced; third, the bulk and weight of the pellets made it impossible to seed at rates sufficiently heavy to insure a stand, and fourth, a considerable proportion of the seeds were damaged in the pelleting process. (Bleak, A. T., and T. A. Phillips. Seedling stands from airplane broadcasting of pelleted and unpelleted seed in southeastern Utah. Research Paper No. 22, 1950).

Future research on seedbed preparation and seeding techniques should include studies of methods of planting on burns and logged areas. Both accidental burns and skid trails provide a large acreage of bared soil each year that should be taken advantage of both for soil protection and to augment range forage. At the same time an evaluation should be made of the effects of range seeding on timber reproduction, for the legitimate objection is raised that grassing over the bare spots may retard natural regeneration of trees. If it should be found that seeded grasses seriously retard establishment of trees, the needs of soil protection and the uncertainty of natural reproduction may require much more intensive tree seeding or planting than in the past. Where competing vegetation is an important factor, research is needed to evaluate rate of seeding in relation to success of stand. Studies of methods should include controlled tests of the effectiveness of trampling by livestock in planting seed on loose, sliding soils and on plowed ground. Tests so far have been inconclusive.

Time of planting

Seed should be planted at a time that will insure sustained contact with moist soil during the early stages of germination and growth, followed by the longest possible period of favorable moisture and temperature. To secure establishment of the young plants, the season of planting should minimize the chances of prolonged drought and of severe freezing during early growth stages. Thus the peculiarities of local climate govern time of planting.

In general, late fall planting is recommended for the Intermountain region. This is planting when temperatures are so low that there is little chance of premature germination and the seeds will lie in the ground until spring. In the aspen and mountain-brush types the broadcast seed will be covered by falling leaves at this season of the year. Another advantage is that stratification (cold treatment), which is provided naturally by fall seeding helps the germination of certain seeds. If the seed is already in the ground in spring the seedling is able to take full advantage of accumulated winter moisture, whereas with spring seeding the ground has to dry enough to permit access with equipment, and since considerable time is involved in a large-scale operation, the effective period for germination and emergence is naturally short. Fall seeding has three disadvantages: early snow storms may put an end to the work before it can be completed, at least some of the seed will fall a prey to rodents or to disease, and at low elevations warm spells in winter may bring on premature germination.

Fall seeding is required particularly in southwestern Idaho and eastern Nevada. Here spring seedings are handicapped by very dry summers. In central and northern Utah at high elevations where summer showers may be expected, seeding may also be done successfully from early spring to midsummer. (Robertson, Joseph H. Season, date, and depth of planting crested wheatgrass and other grasses at lower elevations in northern Nevada. Research Paper No. 14, 1947; Plummer, A. Perry, and John M. Fenley. Seasonal periods for planting grasses in the subalpine zone of central Utah. Research Paper No. 18, 1950.)

There are many exceptions to these generalizations, both from the standpoint of species used and of local site factors. For example, it is better to sow legumes in spring than in fall, since these are likely to germinate after one or two warm days, to minimize likelihood of their being frost-killed. In any case the moisture-retaining power of particular soils and the situation of the seeding site with respect to wind, sun, and cold air drainage must be taken into account.

Phenological studies and correlation of early spring growth with local site factors need to be made in many parts of the region to discover, not so much how to seed a particular flat or hillside, but principles that will insure success under definable site conditions and that can be widely applied.

Management of Seeded Range

Seeded range has been shown to be highly productive as compared with depleted native range (Frischknecht, Neil C., Lorin E. Harris, and Harry K. Woodward. Cattle gains and vegetal changes as influenced by grazing treatment on crested wheatgrass, Jour. Range Mangt. 6(3): 151-158, 1953; Bleak, A. T., and A. Perry Plummer, Grazing crested wheatgrass by sheep, Jour. Range Mangt. 1954, in press).

The basic principles for managing seeded range are similar to those for managing native range. Growth requirements of the preferred species must be given consideration, and season and intensity of grazing so planned that the plants are able to maintain their vigor and reproduce. Uniform distribution of livestock so as to graze the range evenly and at the proper time is as much a desideratum on seeded as on native range.

There are, however, many special questions that need to be investigated on seeded range, since most of the species used are introduced and we are relatively unfamiliar with them. Questions to be considered include palatability, not only to livestock, but to game animals and rodents, tolerance of different species to grazing use, indicators of range trend under grazing, response of mixtures to grazing as compared with pure stands, productivity in terms of animal gain, productivity in terms of crownspread and litter in relation to soil protection, and--particularly important on high watershed lands--moisture consumption.

Not much is known about the grazing resistance of various species although some--crested wheatgrass at low elevations and smooth brome and Kentucky bluegrass at high elevations--are remarkably resistant to heavy use. Relative palatability has been determined in a number of places (Hurd, Richard M., and C. Kenneth Pearse. Relative palatability of eight grasses used in range reseeding. Amer. Soc. Agron. Jour. 36(2): 162-165, 1944). To give a specific example: in eastern Idaho spring grazing tests with sheep have shown that intermediate and pubescent wheatgrasses have been highly palatable, crested, tall, and Siberian wheatgrasses and Russian wildrye have been moderately palatable, and native western and thickspike wheatgrasses relatively unpalatable.

A great deal of research is also needed on the relation between seeded species and natives. The rhizomatous western wheatgrass, for example, may increase in some areas and suppress the more palatable and productive crested wheatgrass. The relation of grazing management to the invasion of sagebrush and rabbitbrush in seeded stands is a matter of great economic importance in the Intermountain region, both on public and private ranges. Grazing management experiments under way at Ephraim and Benmore, Utah, at Ruby Valley, Nevada, and at Dubois, Idaho, are designed to throw light on these questions with respect to crested wheatgrass on lowland ranges. There is need for similar information on a great many other species, particularly those that have been seeded at higher elevations.

Seeded stands of crested wheatgrass and of other species tend to fall off in production after the first four or five years. The causes for this decrease in production are not known. There is a possibility that parasitic organisms such as nematodes may build up to epidemic proportions in pure stands. The decrease may also be related to the fact that these are even-aged grass stands, in contrast to normal, uneven-aged natural populations. Various other explanations such as sod binding and senescence need to be explored.

Management research on seeded ranges should include consideration of the effects of rodents and how damage by rodents to seeded stands may be minimized. The problem of jackrabbit pressure on seeded stands has been particularly serious in parts of northern Nevada. The extent of pocket-gopher damage is a highly debatable point. Studies recently undertaken in northern Utah and Wyoming are intended to throw light on this question and should tell us whether costs of gopher control on seeded areas are justifiable.

The relations of range seeding to watershed management need critical study. The stabilization of depleted and eroding slopes by seeded grasses has been a fundamental in conservation, and there are dramatic demonstrations of such restorative work in the Intermountain region. Nevertheless there are many eroding slopes on which seedings have failed, as has been pointed out under "site factors." These underscore the need for study of the effectiveness of various types of plants and plant communities in covering and holding the soil, especially under use by livestock and wildlife. Furthermore, a knowledge of the drain that various species make on soil moisture may be of considerable importance in planning conservation programs where, as in the Intermountain West, advantage needs to be taken of any and all means of increasing water yield.

Elimination of Undesirable Vegetation

When a range is being overgrazed and the palatable species are being killed without replacement by reproduction of their own kind, less palatable neighboring plants increase or undesirable species invade, utilizing the space. Even when the original native vegetation is so heavily grazed and trampled by livestock that the range appears to be reduced to a vast dustbed, which happened on some subalpine rangelands around the turn of the century, small and inconspicuous annual weeds--opportunists in plant succession--occupy the site. Although these may form but little protective cover, their insignificance is deceptive: by greedily consuming soil water they materially retard establishment of perennials. Many seedings made without eliminating the competition of these apparently insignificant annuals have been utter failures, and we have learned from bitter experience that the vegetation on depleted range must be seriously reckoned with in attempting to seed that range. (Robertson, Joseph H., and C. Kenneth Pearse. Artificial reseeding and the closed community. Northwest Sci. 19(3): 58-66, 1945; Robertson, Joseph H. Responses of range grasses to different intensities of competition with sagebrush (_Artemisia tridentata_ Nutt.) Ecology 28(1): 1-16, 1947.)

The competing vegetation is of many kinds. On subalpine rangeland in central Utah the annual tarweed has been responsible for many failures. Research has shown that cultivation to eliminate tarweed early in summer, before flowering is well advanced and seed has had a chance to form, will permit subsequently seeded grasses to become established. Such treatment also gets rid of other annuals commonly associated with tarweed, particularly knotweed and collomia. On subalpine range, also, common dandelion has been shown to be a serious competitor, and thorough plowing to sever the roots of this weed is commonly necessary before seeding.

Wyethia, a large, taprooted perennial which often occupies the most productive meadow land in the mountains, suppressing associated palatable species, has proved a particularly tough competitor. Deep plowing is the only mechanical means of destroying wyethia; unfortunately this also destroys the forage species associated with it. It has been found in eastern Idaho that wyethia is very susceptible to the hormone spray 2,4-D alone or mixed with 2,4,5-T, and that by spraying well before the wyethia plants reach full bloom, either with ground rig or by airplane, very good kills are obtained. By this method many of the associated forage species are released and the range is improved without need for seeding. (Mueggler, Walter F., and James P. Blaisdell. Replacing wyethia with desirable forage species. Jour. Range Mangt. 4(3): 143-150, 1951.)

On lower mountain lands and foothills, valleys and plains, sagebrush, rabbitbrush, and cheatgrass are the most serious competitors to artificially seeded vegetation. In eliminating these species it is not enough to destroy the existing stand: one must look ahead to minimize the amount of reproduction. In many cases the time of plowing for destroying sagebrush, for example, insures a stand of sagebrush seedlings the following year. Being the same age as the seedling grasses, these have an excellent opportunity for survival and eventual dominance (Blaisdell, James P. Competition between sagebrush seedlings and reseeded grasses. Ecology 30(4): 512-519, 1949; Bleak, Alvin T. Sagebrush seedling production as related to time of mechanical eradication. MS. in preparation.) The principle to follow is destroy the undesirable plants before they seed and to keep animals off the disturbed ground to avoid introducing seed of undesirable species from the surrounding range until the desirable plants have fully occupied the space.

Where there is a fairly good stand of native species as an understory to sagebrush, planned burning has been found an effective means of removing the sagebrush, releasing the understory plants and making them accessible to grazing animals. Some of the better forage species are killed or weakened by burning, however, and the opening of the stand requires careful management to allow them to increase and to prevent reinvasion of sagebrush. Hence, grazing should not be permitted until at least a year after burning. Even with the best of management, however, burning may cause such a loss of desirable species and such an increase of undesirable ones, like horsebrush and yellowbrush which are stimulated by fire to sprout from the roots, that burning is recommended only at long intervals (Pechanec, Joseph F., and George Stewart, Sagebrush burning--good and bad, U. S. Dept. Agr. Farmers' Bul. 1948, 1944; Blaisdell, James P., Ecological effects of planned burning of sagebrush-grass range on the Upper Snake River Plains, U. S. Dept. Agr. Tech. Bul. No. 1075, 1953). Hormone sprays are being applied to sagebrush, although only a little research on this subject has been done by the Intermountain Station, and the effects of these sprays are currently being evaluated.

Where a good residual stand of forage plants is not present beneath sagebrush, seeding is necessary following burning. This is also true when mechanical methods are used which destroy the understory vegetation. Many mechanical methods for removing sagebrush have been developed, including a number of forms of disk plows, pipe harrows, and rails. Each has its advantages under certain conditions (Pechanec, Joseph F., *et al*. Eradication of big sagebrush (*Artemisia tridentata*). Intermountain Station Research Paper No. 10, 1944; Pechanec, Joseph F., *et al*. Sagebrush control. U. S. Dept. Agr. Farmers' Bul. *in press*).

Getting rid of rabbitbrush is more difficult than getting rid of sagebrush. Burning is generally ineffective because rabbitbrush sprouts vigorously and may be thicker than before the fire. Preliminary studies with chemical sprays, too, have mostly proved disappointing. Deep plowing or root planing, severing roots about 6 inches below the surface of the ground, is the best means now known of killing rabbitbrush. Such costly processes are often justifiable where dense rabbitbrush occupies deep soils with abundant subsurface moisture because such sites can be made highly productive of forage.

Cheatgrass is not difficult to eliminate by plowing. As with another annual, tarweed, plowing should be done at a time that will minimize the likelihood of planting the seed. Since cheatgrass is a winter annual, fall or early spring plowing is effective. Burning is effective if done in early summer when the cheatgrass is dry enough to burn readily but just before the seed is shattered, and is of course less expensive than plowing. (Hull, A. C., Jr., and Joseph F. Pechanec. Cheatgrass--a challenge to range research. Jour. Forestry 45(8): 555-564, 1947; Stewart, George, and A. C. Hull, Jr. Cheatgrass (*Bromus tectorum* L.)--an ecologic intruder in southern Idaho. Ecology 30(1): 58-74, 1949).

A particularly interesting instance of the need for controlling competition of cheatgrass is involved in the revegetation of granitic slopes in southwestern Idaho with bitterbrush. This shrub, a valuable winter forage for deer, has been virtually exterminated over extensive areas, not only by overbrowsing but by insect attacks and by repeated cheatgrass fires. Large-scale plantings failed completely some years ago, although the seed was good and the species was obviously adapted to the sites being planted as evidenced by relics of former stands of bitterbrush. Subsequent research has shown clearly that bitterbrush seedlings have a difficult time competing with cheatgrass. It has also been found that other annual weeds, which are abundant when cheatgrass is plowed, retard the growth of bitterbrush. Finally it has been demonstrated that scalping the surface inch or two of soil and planting bitterbrush seeds to a prescribed depth in cleared areas of two or three square feet, effectively removes the seed of all annual weeds for the first year and permits bitterbrush seedlings to get a good start. The scalping process is now being applied successfully in field plantings of bitterbrush by the Idaho State Department of Fish and Game.

Finally there is the problem of eliminating poisonous plants such as sneezeweed, larkspur, and the annual halogeton. Some progress has been made in reducing poisonous plants by using sprays and methods of cultivation, but more research is justified, particularly into the basic ecological and physiological requirements of these plants. In most cases the control of poisonous plants on the range appears to be most successful by means of management rather than by means of direct eradication. This is to say that most poisonous plants become a problem when there is little else on the range for the animals to eat. Conversely, when the range is producing an abundance of forage the poisonous plants are little eaten and their spread is checked. This indirect control with perennials seems to be the only alternative with the annual halogeton, although the use of chemicals and methods which disturb the competing vegetation may have application under special conditions. Their effect on the range in general is only to entrench halogeton more firmly and to insure its spread. Vigorous native perennials and artificially seeded grasses, while not able to exclude halogeton completely, generally appear able to hold it to harmless proportions.

A great deal of progress has been made in the development of heavy equipment for controlling undesirable plants and for seeding on the range. Most drills, plows, and harrows usable for farm work are not sufficiently rugged for the irregular terrain, steep slopes, rocks, and obstructions found on the range. A notable achievement among a number of others by the Forest Service Range Reseeding Committee has been the development of the brushland plow, a modification of the Australian stump-jump plow. This committee has provided an opportunity to pool experience, to get expert engineering help, and to test equipment in a coordinated program under all kinds of field conditions. The committee has included representatives from Forest Service administrative regions and range experiment stations, Arcadia Equipment Center, Bureau of Land Management, Indian Service, and Soil Conservation Service. The several agencies have contributed financially to the development of improved equipment. In view of organizational changes, reorganization of this committee and perhaps a redefinition of its functions are now in order.

Research should be continued on equipment to devise more and better means of brush control, contour terracing, and seeding. Equipment is needed to perform well under difficult conditions, as on skid trails and steep slopes. Seeding equipment, which at present is adapted to the grainlike seeds of agricultural crops, needs to be developed to handle the chaffy seeds of certain grasses and winged and bracted seeds of many shrubs and forbs.

Progress in many parts of the world has been made in the control of undesirable plants by the use of insect parasites. Notable examples are the control of cactus in Australia and of St. Johnswort there and in this country. It has been observed in southern Idaho and northern Nevada in recent years that extensive areas of sagebrush have been defoliated and killed by insect parasites, some of which have been isolated. A cooperative study with Brigham Young University has been undertaken to ascertain the insect fauna of the sagebrush-grass community and lay the foundation for further research. The study is not yet sufficiently advanced to give an indication as to whether insects may be used for elimination of sagebrush where this is considered desirable for range improvement. The role of rodents in controlling undesirable brush also warrants more study: in some years the evidence of mice and rabbit work is very impressive.

Study of problems of eliminating undesired vegetation is still in its early stages. A better understanding of ways and means for effective and cheap control is of course important. Parallel with such study, however, should go research to ascertain how the range may be improved with a minimum of destruction to native forage species. The respective forage and soil-protective values of mixed native vegetation and artificially seeded vegetation need to be better understood. Management techniques for control of undesirable species are particularly important. Such techniques must be based on the physiological and phenological characteristics of plants to be controlled and their ecological relations to other vegetation on the range. This need is particularly acute with cheatgrass in the Intermountain region.

The question of brush burning on slopes is an important one which requires study from the standpoint of soil erosion. Burning in the mountain brush type, involving a great many species in a wide variety of site conditions, deserves careful study because the practice is harmful in some respects as well as beneficial in others. A special problem is posed by the practice of clearing blackbrush (Coleogyne) in southern Nevada by burning, in the expectation of freeing the ground for a crop of annuals for livestock forage. Like burning elsewhere, this practice may be very damaging to watershed values.

The effects of chemicals as well as of fire and tillage, on the valuable species in the native stand, either from the standpoint of protective cover or as forage for livestock or wildlife, need to be carefully evaluated. There is considerable fear, for example, that indiscriminate use of hormone sprays on wyethia or sagebrush may reduce valuable forbs and shrubs in the cover. (Nothing is known, either, about their effect on soil organisms and soil structure.) Furthermore it must be recognized in each locality that species which are "undesirable" for one class of animals may be an important element in the diet of another. Game specialists are understandably concerned at wholesale destruction of species like bitterbrush, sagebrush, and juniper which may further restrict winter range for deer. Such concern calls for factual information on which a sound multiple-use range-improvement program can be based.

HIGHLIGHTS OF RANGE RESEARCH IN 1953

Artificial Revegetation

Grasses for Copper Basin, Idaho

Although Copper Basin on the Challis National Forest is between 7,500 and 8,500 feet above sea level, the vegetational aspect there is more like that of the lower, drier Snake River Plains than like most other high-altitude ranges in south-central Idaho. Big sagebrush (Artemisia tridentata) and black sagebrush (A. nova) predominate, with a poor to good stand of several low-producing grasses in the understory. It has been thought that species known to be adapted for artificial revegetation in the lower sagebrush-grass zone might not be useful in this area because of the shorter growing season at the higher elevation. In 1949 and 1950, in conjunction with an administrative trial of reseeding methods, the Intermountain Station established a series of plots to test 43 strains of 32 herbaceous species for adaptability to this area. The summer of 1953 was the third and fourth growing season for these species. In that year 11 strains of 8 species were outstanding in herbage yield, production exceeding by two to three times that of surrounding undisturbed native sage-grass range. In descending order of total yield they were: Primar slender wheatgrass, Manchar smooth brome, Fairway crested wheatgrass, streambank wheatgrass, commercial slender wheatgrass, standard crested wheatgrass, big bluegrass, Russian wildrye, meadow brome, commercial smooth brome, and intermediate wheatgrass. These species are not only more productive than the depleted native cover, but they remain green and succulent for a longer period.

It is still rather early to recommend species for artificial revegetation in Cooper Basin and similar areas. Some of the grasses take longer to reach full stand maturity than others. Observations over a longer period will show which species are most persistent, and these species should be the ones planted in any large-scale program. Slender wheatgrass is a short-lived species, and between 1952 and 1953 several plants died. It dropped from first in yield in 1952 to sixth in 1953. On the other hand, big bluegrass, with slower maturing, longer-lived plants, promises to be relatively more productive in the future than it was in 1953.

Control of Medusa-head Wildrye

Medusa-head wildrye (Elymus caput-medusae) is an aggressive winter annual only recently recognized as a range pest in southwestern Idaho. In the past decade it has invaded thousands of acres of former cheatgrass range in Gem, Payette, and Washington Counties. It has the same inflammable characteristics as cheatgrass but is far less desirable as forage. In 1952 plots were established in medusa-head to determine the effect of moldboard plowing, disking, and burning preparatory to reseeding with perennial grasses. There was no germination of medusa-head in the fall of 1952. Germination began during the warm, moist January of 1953. The spring season in 1953 was unusually damp, and spring rains lasted until well into June.

Numbers of medusa-head plants per square foot and production in 1952 are shown in table 3.

It is notable that, although plowing and early disking were very effective in reducing the number of plants of medusa-head in the stand, these tillage treatments resulted in greater volume of growth than on the undisturbed plots. On plots with the greatest number of plants, i.e., on the late summer disked plots, the November burns, and the undisturbed plots, the medusa-head did not tiller, but where the stand was reduced by more effective treatment most plants had several culms, and total plant height was greater.

Burning in July and August, under conditions prevailing in 1952, was most effective in reducing both numbers of plants and 1953 production.

Table 3.--Effect of plowing, disking, and burning on medusa-head wildrye

Treatment	Wildrye plants, spring, 1953	Air-dry herbage, July, 1953
	no. per sq. ft.	lb. per acre
Plow 5/16/52-before seed maturity	18	4,483
Disk 5/16/52- " " "	83	3,727
Burn 6/7/52- " " "	81	2,692
Burn 6/17/52-seed in soft dough	107	2,105
Burn 7/5/52	45	1,785
Burn 8/6/52	88	1,682
Burn 9/9/52	106	2,432
Disk 9/9/52	201	2,603
Burn 11/22/52-seed fallen	286	2,248
Undisturbed	744	3,665

Scalping to Eradicate Annual Weeds

The winter ranges of the Payette and Boise River deer herds are mostly steep, south-facing granitic slopes with an annual weed cover and a scarcity of browse in many places. Browse revegetation studies made in the past 5 years with the cooperative help of the Idaho Fish and Game Department have shown reduction of competing vegetation to be necessary for successful establishment of browse seedlings. It has been found that most of the annual weeds can be eliminated for a season if the surface inch or so of soil, which contains the seeds, is scraped from spots to be planted. It appears that the competitive effect of surrounding weeds is not felt by browse seedlings in the central part of plots more than 2½ feet across. Weed control by scalping can be combined with planting, the simple once-over operation being considerably cheaper than separate weed-control and planting treatments.

Table 4 shows a marked reduction in weeds as a result of scalping. Supplemental information indicates that the effectiveness of date depends partly on the time of maturity of weed species: scalping is about equally effective at all times during summer and fall with early-maturing species like cheatgrass and filaree, as in the table, but late scalping is most effective with late-maturing species like knotweed and kitchenweed. The slight advantage in scalping to a depth of 2 or 3 inches rather than 1 inch on this undisturbed site might be more pronounced on soils in which seeds have been deeply buried by trampling.

Table 4.--Effect of scalping on weed numbers in subsequent years

Treatment	Weeds per sq. ft.	
1951 Series		
	1952	1953
Not scalped	116.8	104
Scalped 3 inches, August '51	3.3	26
Scalped 3 inches, November '51	1.1	23
Scalped 1 inch, November '51	1.7	20
1952 Series		
Not scalped		114.0
Scalped 2 inches, October '52		1.7
Scalped 1 inch, October '52		1.9

Effect of Season of Eradication on Production of Big Sagebrush Seedlings

Big sagebrush (Artemisia tridentata) blooms during late summer and early fall depending on elevation and current climatic conditions. In the Intermountain region ripe sagebrush seed has been produced by the middle of September at high elevations but at low elevations seed may not ripen until the latter part of November.

Sagebrush eradication and grass seeding were done on two large adjacent projects in Humboldt County, Nevada, during the spring, summer, and fall of 1952. These projects, encompassing over 10,000 acres of range administered by the Bureau of Land Management, are representative of much depleted sagebrush land in this section of Nevada. The elevation is approximately 6,000 feet and average annual precipitation about 8 inches.

Offset disk harrows and wheatland-type plows were used to eradicate the brush. On one project brush eradication was started in the latter part of April and completed in early September 1952. On the other project eradication was started in early September and continued until the middle of November when work was stopped by winter storms. These areas were seeded to crested wheatgrass in the late summer and fall.

In 1953 counts were made of sagebrush seedlings and mature plants on the cleared land. Plots were located at 50-foot intervals on random transects at right angles to the line of brush eradication. One hundred plots were taken in each area sampled. Results are shown in table 5.

Table 5.--Average number of seedlings and mature sagebrush plants per 10 sq. ft. on areas worked during the spring, summer, and fall, 1952

Time of eradication	Number of plants: Mature	Number of plants: Seedlings
April-May	0.17	0.33
July-August	.09	.01
August-September	.04	.01
September	.03	.04
October	.09	.20
October-November (first area)	.06	2.17
October-November (second area)	.10	6.00

The number of mature plants remaining after treatment decreased as the work progressed from spring through summer, but increased again on areas worked in October and November. The large number left on areas worked in spring probably resulted from greater flexibility of the brush in the spring and from a good supply of soil moisture which enabled partly uprooted plants to become reestablished. These plants produced many seed stalks in contrast to those that survived on areas worked in summer and fall. This is attributed to favorable growing conditions in the spring and early summer of 1952.

Few sagebrush seedlings were found where brush was eradicated during the summer, July through September. Greater numbers of seedlings were found on areas worked either in early spring or in early fall, and by far the most were found where brush was eradicated in late fall. The moderate number of sagebrush seedlings on the area worked in early spring is attributed to seed produced in the fall of 1952 by the 0.17 mature bush per 10 sq. ft. that had not been killed. The large number of sagebrush seedlings on areas worked from early October to mid-November is attributed to the mature sagebrush seed then on the bushes. As confirmatory evidence, sagebrush seedlings are frequently found clustered close to the crowns of dead sagebrush plants that have been uprooted.

These observations show that sagebrush eradication by plowing, disking, or railing is most effective in midsummer, primarily because the opportunity for sagebrush reproduction is minimized then. Mechanical eradication after the seed is mature, on the other hand, is likely to result in a new stand of sagebrush. The mechanical operation reduces the competition of established vegetation, loosens the soil and provides a seedbed, scatters ripe seed, and covers at least part of it.

First Year Observations on a Large-Scale Subalpine Seeding

In 1952 a 435-acre cooperative seeding of a depleted subalpine watershed was undertaken with the Manti-LaSal National Forest in the head of Manti Canyon. The weedy vegetation included sticky geranium, sweetsage, Rydberg penstemon, tongueleaf violet, and common dandelion. In 1955 or 1956, depending on stand establishment, a grazing study with cattle is to be started on the seeded and a comparable unseeded range to evaluate seeding from the dual point of view of forage and watershed improvement.

To eliminate weedy vegetation and prepare a seedbed the Towner-Meyer offset disk, brushland plow, and rockland tiller were used. In 1952 when the plowing was done, there appeared to be little difference in the amount of weedy growth eliminated by the offset disk and brushland plow. Observations in 1953 showed that the offset killed 85 percent of the weedy growth, whereas the brushland killed 60 percent. This difference is attributable to the greater depth of plowing by the heavy offset (5 to 7 in.) than by the brushland (3 to 4 in.). Reflecting better kill of weeds, better seedling establishment was found on the offset- than on the brushland-treated areas, with establishment rated "good" and "fair," respectively. Whether the difference in kill warrants the difference in cost between $9.01 per acre for the offset and $4.32 per acre for the brushland, remains to be seen.

The rockland tiller was an experimental implement with ripper teeth arranged to eliminate weedy competition in rocky areas. The teeth operate on springs so that when imbedded rock is struck tension is released and the teeth jump out of the ground, then automatically go back in. While this machine was primarily used in rocky areas it was also used on small interspaces having deeper soil. Kill of perennial vegetation by the tiller was only 29 percent, and seedling establishment was rated "poor," which again emphasizes the importance of eliminating competition. The rockland tiller cannot be compared directly with the other implements because the land treated with it included rocky, harsh sites that could not have been treated with either the brushland or offset.

A seed mixture composed of smooth brome, tall oatgrass, meadow foxtail, timothy, orchardgrass, and alsike clover was broadcast on the loose seedbed. Natural soil sloughing was sufficient for covering the seed. While seedlings of most species were represented in the stand, orchardgrass was most evident. Most of the area was seeded with power broadcasters; part of the time a broadcaster was mounted on the brushland plow and the land sown at the same time ground was plowed. This resulted in better seedling stands than where the area was broadcast later in a separate operation. On comparable areas, stands seeded by a power broadcaster mounted on a wheel tractor generally resulted in better stands than those broadcast by hand, and this is attributed to the more uniform distribution achieved by the power broadcaster.

Persistence of Species at High Altitudes

The hazard of basing recommendations of species to use in artificial revegetation on only a few years' observations was forcefully demonstrated in 1953. In mountain meadows and on a timber burn in the subalpine zone in central Idaho, timothy and orchardgrass grew most vigorously and were among the most promising species in 1952. Between 1952, the third growing season, and 1953 there was a near-total loss of orchardgrass, even on some of the moister sites, and with timothy the result was almost as bad.

The high mortality of what had been vigorous plants is thought to be related to the unusually long, dry season in the latter part of 1952. The fall months were among the driest on record, the drought ending only after the weather had become very cold in November.

Alfalfa Tests in Central Utah

Crying needs exist in range seeding for adapted legumes. In the 1952 Annual Report, p. 32, a summary of alfalfa strain trials was given on good and fair mountain-brush sites. On the good site in 1953 (the third growing season) sickle alfalfa (*Medicago falcata* SCS P-550) was the highest-yielding strain. It was followed in order by Ladak, Ranger alfalfa x *Medicago glutinosa*, Grimm, and Rhizoma. At the drier site, despite heavy utilization by deer and rabbits, it appeared that sickle alfalfa was also best. Because sickle alfalfa and Ranger alfalfa x *M. glutinosa* appear to be superior, seeds of these are being increased by the Agricultural Research Service so that plantings can be expanded.

Grass-Legume Mixtures in the Mountain-Brush Zone

Mixtures of four grasses and nine legumes were established in the mountain-brush zone of central Utah in 1950. Observations made in 1953, the third growing season, have shown that, in general, a grass-legume mixture will produce more pounds of forage than either the grass or legume planted alone. Legumes and grasses can either be mixed together in the rows or planted in alternate rows; the effect remains the same. As would be expected, the highest total yield came from a mixture of the highest yielding grass (intermediate wheatgrass) and the highest yielding legume (chickpea milkvetch). The lowest total yields were the mountain brome-legume mixtures, a result of the very low yields of mountain brome itself; and as a corollary the highest legume yields were for those planted with mountain brome. Average total yields for smooth brome-legume and crested wheatgrass-legume mixtures were almost identical, but the smooth brome mixtures contained almost twice the amount of legumes and a lower grass yield. The better legumes accounted for only 9 percent of the total yield with intermediate wheatgrass, 13 percent with crested wheatgrass, 21 percent with smooth brome, and 49 percent with mountain brome.

The highest-yielding grass in these tests was intermediate wheatgrass, followed by crested wheatgrass, smooth brome, and mountain brome. High-yielding legumes were chickpea milkvetch, *Medicago glutinosa* x Ranger alfalfa, Ladak alfalfa, Rhizoma alfalfa, and sicklepod milkvetch. The low-yielding group included sickle alfalfa, birdsfoot deervetch, bramble vetch, and flat peavine.

Seeding Rate of Crested Wheatgrass in Southeastern Idaho

Although much progress has been made in selection of species and methods for artificial seeding in the Intermountain region, the effect of seeding rate upon stand establishment and eventual forage production has been subject to considerable speculation. It is generally believed that too little seed will result either in stand failure or retarded development of a full stand, whereas application of too much seed may cause severe competition between young seedlings, again resulting in stand failure or suppressed stands with inferior yields. In an attempt to clarify the effects of seeding rate on crested wheatgrass, tests were made of drilling at 2, 4, 8, 12, and 24 pounds of seed per acre. The 2-pound rate is considered very light and the 24-pound rate extremely heavy. Replications of each seeding rate were made on three different areas and in three consecutive years. No grazing was permitted during the period of study.

The effect of seeding rate was most apparent during the first 3 years after planting. Within this period stands seeded at 2 and 4 pounds per acre contained fewer plants per square foot and on the whole were not as successful as stands seeded at 8, 12, and 24 pounds per acre. Initial differences became progressively less, until in the sixth year all stands were producing about the same amount of herbage regardless of seeding rate.

Seedling mortality was severe in the heavy seedings during the first 3 years when seedling density in one stand was reduced from 15.7 to 2.2 plants per square foot. In this same period stands with originally less than 1.5 plants per foot tended to increase to what is apparently the optimum this range can support, 1.5 to 2 plants per square foot.

Although there were no differences in quantity of herbage after the stands were well established, there were slight differences in herbage quality and fullness of drill rows. Individual plants of the 2- and 4-pound seedings produced coarser herbage and more flower stalks than those from the heavier seedings. After 7 years drill rows in the lighter seedings were no longer well defined.

On well-prepared seedbeds on the Upper Snake River Plains a seeding rate of 8 pounds of crested wheatgrass is adequate, but heavier seedings are not deleterious and may produce initially superior stands. Seeding rates as low as 2 pounds per acre will eventually produce satisfactory stands, even though they may have very few seedlings during the first growing season, if the grass is given sufficient protection. Ultimate herbage production is dependent upon site potential and climatic conditions rather than rate of seeding.

Preferences of Sheep and Cattle for Grasses

Two pilot plantings near the edge of the juniper-pinyon belt in central Utah include several promising grasses which are now being subjected to grazing in May. One test, grazed by cattle, includes 16 species drilled in mixture with crested wheatgrass; the other, grazed by sheep, includes seven species planted alone.

One objective of the study is to ascertain relative persistence of the grasses when they are grazed to 65 to 70 percent by the end of the spring growing season. The study is not yet sufficiently advanced to give answers on this point. Another objective is to ascertain grazing preferences as shown by utilization estimates midway in the grazing period. Estimates for 1953 are given in table 6.

Both sheep and cattle showed a preference for intermediate and pubescent wheatgrasses and for Russian wildrye. They sought out Russian wildrye the first few days. Deer, grazing the plantings in March and April showed a high preference for these same species, especially Russian wildrye.

Low preference for tall wheatgrass may be attributed to the carryover of coarse stems from the previous year obstructing use of green forage in the base of the plants, but low preference for bearded bluebunch wheatgrass by sheep and thickspike and bluestem wheatgrasses and mountain rye by cattle is not to be explained in this way. It is noteworthy that crested wheatgrass and bearded bluebunch wheatgrass are more highly preferred by cattle than by sheep. Differences in utilization between species became less evident as grazing progressed.

Table 6.--Utilization of various grasses by sheep and cattle, midpoint of grazing period, 1953

Species	Sheep use	Species	Cattle use
	percent		percent
	High Preference		
Intermediate wheatgrass	53	Big bluegrass	50
Pubescent wheatgrass	50	Pubescent wheatgrass	40
Russian wildrye	50	Intermediate wheatgrass	38
		Crested wheatgrass (Fairway)	38
		Crested wheatgrass (Turkestan)	38
		Bearded bluebunch wheatgrass	38
		Crested wheatgrass (standard)	35
		Russian wildrye	35
	Intermediate Preference		
Crested wheatgrass (Fairway)	30	Beardless bluebunch wheatgrass	30
Crested wheatgrass (standard)	20	Giant wildrye	30
		Smooth brome	22
		Indian ricegrass	20
	Low Preference		
Bearded bluebunch wheatgrass	10	Thickspike wheatgrass	15
Tall wheatgrass	7	Tall wheatgrass	15
		Bluestem wheatgrass	10
		Mountain rye	10

Persistence of Seeded Grasses in the Mountain Brush Zone

Twenty-two grasses were seeded with smooth brome on contour strips 400 feet long and 8 feet wide following burning in 1944 in the mountain-brush zone (8,200 ft. elev.) of central Utah. Two transects were established across all plots in 1946, and one was fenced for a comparison of the persistence of grasses under protection and under grazing. The fenced transect has been totally protected from livestock grazing except for the late summers of 1948 and 1949 when cattle broke through the fence and utilized the grass to about 80 percent. The unfenced transect has been grazed very heavily by livestock until 1952. In 1952 it was fenced, when utilization averaged about 50 percent, to provide a comparison in 1953.

In 1953 intermediate and pubescent wheatgrasses, quackgrass, and meadow brome showed continued superiority over smooth brome under both heavy grazing and protection.

Beardless bluebunch wheatgrass and big bluegrass, two bunchgrasses, increased and tended to suppress smooth brome on the protected transect but not under grazing. Conversely, three sod formers--thickspike wheatgrass, creeping wildrye, and bluestem wheatgrass--increased under grazing at the expense of smooth brome but not under protection. The primary weakness of these five species, along with bearded bluebunch wheatgrass, giant wildrye, subalpine needlegrass, and reed canarygrass, was their initially poor stand establishment.

Mountain rye, mountain brome, bearded wheatgrass, slender wheatgrass, tall oatgrass, blue wildrye, and Canada wildrye are relatively short-lived bunchgrasses which were dominant early, but later these were mostly replaced by smooth brome on both transects. Crested and tall wheatgrass, two longer-lived bunchgrasses, are gradually giving way to smooth brome. (These two grasses are more successful in competition with smooth brome at lower elevations.) Nearly all these grasses have a value in mixture with slower-developing grasses like smooth brome in obtaining rapid establishment of a grass cover following seeding.

Grass yield in 1953 on the transect that had been heavily grazed was only 56 percent of that on the protected transect. This reflects the detrimental effect of heavy grazing on grass vigor, because yields on the two transects were comparable at the outset. It was observed nearby, however, that 1 year of complete protection following several years of heavy grazing resulted in almost complete recovery of grass vigor.

Response of Brush to Grazing Seeded Grasses

Table 7 shows the response of brush to grazing and protection of the seeded grasses in the foregoing study. Many sagebrush seedlings became established with the grasses and have grown in stature, but a high proportion have died. The mortality has been materially heavier under protection than under heavy grazing. Furthermore, new seedlings have invaded the heavily grazed area in force, but not the protected area. Aside from the factor of grass competition, the heavy grass litter in the enclosure, amounting to about 3,000 pounds per acre, is probably effective in excluding sagebrush seedlings. The effect of grass competition is strikingly shown in the yields of sagebrush, which has been practically ungrazed: the volume of sagebrush on the protected

Table 7.--Response of big sagebrush, mountain snowberry, and chokecherry to heavy grazing and protection of seeded grasses

	Protected transect	Heavily grazed transect
Big Sagebrush		
Seedlings, no./sq. ft.		
1946	1.03	0.83
Survival, 1953	.30	.35
New seedlings, no./sq. ft.		
1951	0	.044
1952	0	.087*
1953	.003	.280*
Yield, lb./acre, air-dry		
1946	94	59
1953	505	1,040
Mountain Snowberry		
Yield, lb./acre, air-dry		
1946	479	539
1953	477	1,023
Chokecherry		
Sprouts, no./transect		
1946	46	177
1953	40	24
Yield, lb./acre, air-dry		
1946	24	22
1953	43	9

* Includes new seedlings previously recorded

transect increased 5.4 times in the 8 years 1946 to 1953, while that on the grazed transect increased 17.6 times.

Mountain snowberry, unlike sagebrush, was not killed by the fire, but sprouted vigorously from the crown. Utilization of the current growth of snowberry on the grazed area has varied between 10 and 60 percent in different years. Yield on the protected transect has remained essentially constant, doubtless because of suppression by the grasses. On the grazed transect, in contrast, yield of snowberry has almost doubled, partly perhaps because the shrubs have been stimulated by moderate grazing, and partly because competing grasses have been handicapped by heavy grazing.

Chokecherry also sprouted after the fire. The sprouts have been utilized heavily each year--about 90 percent--on the grazed area. This utilization is reflected in greatly reduced production under heavy grazing as compared with complete protection.

Spring-Fall Range

Winter Rye Compared with Crested Wheatgrass

Ewes and lambs have grazed comparable winter rye and crested wheatgrass pastures in central Utah for 3- to 5-week periods in late April and May the past 11 years. When there has been sufficient regrowth, pastures have also been grazed in the fall.

Gains and grazing use obtained have been very similar on the two types of forage as shown in tables 8 and 9. Lambs averaged over 1/2 pound daily gain and ewes averaged about 1/3 pound daily gain on both grasses. Both furnished very nearly the same sheep-months' grazing. Because of the variations between years, differences in the averages are not significant.

This experiment has demonstrated that with proper management rye pastures can be maintained for several years where average annual precipitation may be no more than 10 inches. By 1952, two annuals, cheatgrass brome and _Malcomia africana_ (an early spring-growing exotic mustard), had seriously encroached on the rye. While there was a fair stand of rye in 1953, these annuals had increased so much that it was evident they would severely curtail future production of rye.

An advantage to rye is that it will furnish forage the spring following fall planting, whereas crested wheatgrass seedings must be protected from grazing for a year or more. To insure continuing stands of rye, however, livestock must be removed in late May or early June to allow it time to mature seed. When grazed in the fall, care must be taken to see that enough seed has fallen on the ground for the next year's crop. With only 10 inches of annual precipitation it is usually necessary to disk in the fall to cover the seed. Except for 3 years, the rye in this study was disked.

Table 8.--Spring gains by lambs and mother ewes on crested wheatgrass and rye pastures, 1943-53

Year	Lambs		Ewes	
	Crested wheatgrass	Rye	Crested wheatgrass	Rye
	Pounds per day			
1943	0.50	0.65	0.48	0.52
1944	.52	.54	.80	.54
1945	.51	.49	--	--
1946	.51	.56	.14	.13
1947	.42	.36	.00	.16
1948	.58	.55	.19	.38
1949	.48	.54	.23	.29
1950	.72	.75	.24	.09
1951	.70	.66	.22	.44
1952	.69	.66	.93	.54
1953	.65	.66	.23	.06
Average	.57	.58	.35	.31

Table 9.--Sheep months per acre from crested wheatgrass and rye pastures, 1943-53

Year	Crested wheatgrass			Rye		
	Spring	Fall	Total	Spring	Fall	Total
1943	3.6	1.3	4.9	5.7	--	5.7
1944	5.0	2.2	7.2	5.1	3.1	8.2
1945	6.5	1.7	8.2	6.5	2.3	8.8
1946	4.3	1.2	5.5	2.9	--	2.9
1947	5.5	2.0	7.5	4.9	1.8	6.7
1948	4.8	.9	5.7	3.9	--	3.9
1949	4.3	.8	5.1	3.4	--	3.4
1950	3.5	--	3.5	3.6	--	3.6
1951	2.5	--	2.5	3.7	--	3.7
1952	2.4	--	2.4	1.7	--	1.7
1953	2.6	--	2.6	1.9	--	1.9
Average	4.1	0.9	5.0	3.9	0.7	4.6

Once established, crested wheatgrass is more dependable than rye. It furnishes grazing approximately 2 weeks earlier in the spring than rye, and no additional expense is incurred to keep it in production. These factors, together with the better grazing furnished in the fall, suggest that crested wheatgrass is superior for permanent pasture on spring-fall range.

Deer-Cattle Range Relations

On the Oak Creek unit of the Fishlake National Forest about a fifth of the summer range and a third of the winter range are used heavily by both deer and cattle. Such areas of dual intensive use are the areas of most severe competition and are the key areas upon which management of the range should be based.

Studies throughout Utah show that forbs and browse make up the bulk of the summer deer diet, the proportions of each depending on the amount of palatable species of each class present. Grass makes up a large part of the summer diet of cattle wherever it is available, but on areas where grass is depleted cattle feed largely on browse and forbs. Most of the choice deer forage species are utilized to some extent by cattle, but grass, the choice cattle forage, forms a negligible part of the deer summer diet.

Deer feed chiefly on browse in winter. Some choice deer browse species are also palatable to cattle in spring and fall. Several browse species, cliffrose (*Cowania stansburiana*), curlleaf mountain-mahogany (*Cercocarpus ledifolius*), and big sagebrush (*Artemisia tridentata*), supply a substantial part of the deer winter diet but are used but little by cattle in spring and fall. Grasses, which are preferred forage for cattle in all seasons, are used heavily by deer for only a short period in early spring.

Forage competition between deer and cattle varies from very light to severe depending on several factors, chief of which is degree of overstocking. In most cases proper use of perennial grasses limits the cattle grazing that can be sustained. Likewise proper use of choice browse and forbs limits the amount of grazing by deer. However, for maximum sustained grazing by both deer and cattle, proper use of the forbs and browse palatable to both kinds of animals is essential.

FOREST ECONOMICS INVESTIGATIONS

The main effort of this Division last year was devoted to a study of the benefits and costs which should be considered in managing a range-watershed. The study was limited to the water and livestock forage resources in order to simplify the analysis.

In the initial phase of this study a method was developed for estimating the community returns and costs involved in the management of each of the two wild-land resources. The method requires the compilation of the monetary values which accrue in the processes of producing water and livestock forage.

The community returns from water production for the purposes of this study were limited to the returns derived from the use of irrigation water. These returns accrued to irrigation farmers, the farm wage earners, investors, and to the local public in the form of taxes on irrigation farming enterprises. The community returns from livestock forage production included the returns to the grazier, his laborers, the investors, that portion of the Federal grazing fee which is returned to the local community in lieu of taxes, and the local taxes on the range livestock operations.

The community costs involved in the production of water and livestock forage included: (1) expenditures for control of erosion and floods; (2) the damages caused by erosion and floods; (3) the income that is sacrificed by reducing grazing use on the watershed; and (4) the income that is sacrificed due to restricted agricultural production on the flood plains.

This technique of estimating community returns and costs was applied to three assumed situations on the range-watershed lands of Davis County, Utah to determine its usefulness as a wild-land management aid. The three assumed situations were as follows: (1) The present situation characterized by a small amount of livestock grazing use and maintenance of a partial program of erosion and flood control measures; (2) a future situation in which all livestock grazing is eliminated and the remainder of planned watershed improvement measures are installed; and (3) a modification of the foregoing situation in which only those watershed improvements and livestock grazing adjustments were included which had a favorable effect on community income.

The results of these analyses show that plan 2 as outlined above would increase community income above that derived from the present situation by $2,700 annually. Plan 3, however, would increase community income above the present by $5,600 annually. It should be recognized that these values did not include community income from the wildlife, recreation, or timber resources of the watershed lands, nor did it include secondary benefits such as income derived from local transportation, wholesaling, retailing, processing, and servicing enterprises which are dependent wholly or in part upon the water and range forage production. Even with these omissions, the application of the method of determining community benefits in the Davis County area indicated its usefulness for planning economically desirable range-watershed management programs. The details of this method are to be published in a Station Research Paper in 1954.

In addition to the study in the Davis County area, the community income concept was used in two other papers which are now in process of review. These are "A procedure for estimating monetary values of range seeding" and "An economic approach to deer and livestock grazing."

A doctoral dissertation based on the community income studies, "Primary money income from range-watersheds," has been accepted by the Graduate Division of the University of California for the February 1954 graduation group.

Current statistics on water production and use, timber, recreation, wildlife, range forage, livestock, and land ownership in the 11 western states are of interest to many people in the Intermountain region. National forest administrative personnel need these facts in planning their management activities and in keeping the people of their communities informed on the work they are doing. These statistics were assembled from various sources and published as Station Research Paper No. 31 entitled "Statistical tables on western wild-land resources."

Complete cost records on 17 national forest range seeding projects installed in 1947 were analyzed, discussed with personnel in national forest administration, and a report entitled "Economic value of some R-4 seeding projects" was prepared to suggest to administrative men what can be done to assemble data on benefits which may be evident after the 6 years these seeding projects have been used.

A panel discussion on "indirect and secondary effects of range improvement and problems of measuring them for economic research" was participated in at the meeting of the range economics committee of the Western Agricultural Economics Research Council.

PUBLICATIONS

A. Departmental publications

BLAISDELL, JAMES P. Ecological effects of planned burning of sagebrush-grass range on the Upper Snake River Plains. U. S. Dept. Agr. Tech. Bul. 1075, 39 pp., illus. 1953.

A report of long-term effects of planned burning on vegetation and soil. Such burning is ultimately beneficial to shrubs with a strong sprouting habit and to rhizomatous grasses and forbs, but nonsprouting shrubs, suffrutescent forbs, and some of the finer bunchgrasses are severely injured. Some soil properties are slightly altered by burns of heavy intensity, but such changes are only temporary.

HUTCHINGS, SELAR S. and GEORGE STEWART. Increasing forage yields and sheep production on Intermountain winter ranges. U. S. Dept. Agr. Cir. 925, 63 pp., illus. 1953.

Summarizes results of 14 years experimental study on winter sheep ranges to ascertain utilization of forage by sheep, influence of precipitation on herbage production, effects of grazing intensity on forage yields, and effects of grazing intensity on sheep and wool production. Grazing guides are given for improved management to increase forage and sheep production. Results should be applicable to the salt-desert shrub areas which comprise approximately 43 million acres, or 66 percent of the winter range within the Intermountain region.

B. Publications in scientific and professional journals

CROFT, A. R., and L. V. MONNINGER. Evapotranspiration and other water losses on some aspen forest types in relation to water available for streamflow. Trans. Amer. Geophys. Union 34(4): 563-574. 1953.

Presents results of 3-year plot study on high elevation watershed lands in northern Utah. Amounts of annual precipitation, water losses, and water available for streamflow as well as amounts of summer storm runoff and erosion on normal aspen-herbaceous sites are compared with those on similar sites from which aspen trees were removed by cutting and from which all vegetation and litter were removed by cutting and burning.

FENLEY, JOHN M. Reseeding sagebrush rangeland in Nevada. Jour. Forestry 51(5): 337-338. 1953.

Methods of clearing sagebrush and recommendations for planting.

FRISCHKNECHT, NEIL C., LORIN E. HARRIS, and HARRY K. WOODWARD. Cattle gains and vegetal changes as influenced by grazing treatments on crested wheatgrass. Jour. Range Mangt. 6(3): 151-158. 1953.

This article reports results of the first 4 years of grazing cattle on 24 100-acre pastures of crested wheatgrass at Benmore. The study involves all combinations of three intensities and four methods of grazing.

JULANDER, ODELL. Deer and livestock competition in Utah. Proc. 32nd Ann. Conf. Western Assn. State Game and Fish Comm. (June 1952). 79-85, illus. 1953.

Possibilities and wide variations in extent of competition between deer and livestock. The various factors which affect deer and livestock distribution, forage preferences, and competition for forage, are discussed.

PACKER, PAUL E. Effects of trampling disturbance on watershed condition, runoff, and erosion. Jour. Forestry 51(1): 28-31. 1953.

Presents results of findings from 125 infiltrometer plots on wheatgrass and cheatgrass range watershed lands in southwest Idaho having coarse, loose soil derived from granite. Watershed management implications are discussed.

SMITH, JUSTIN G., and ODELL JULANDER. Deer and sheep competition in Utah. Jour. Wildlife Mangt. 17(2): 101-112. 1953.

Seasonal forage habits of deer and sheep as determined by a study in central Utah, pointing out some of the possibilities of overlap both in diet and in area used.

C. Miscellaneous processed reports

HOLMGREN, RALPH C. Progress report for 1952 (fourth annual report): Cooperative research program for revegetating the deer winter ranges on the Payette and Boise River drainages. Processed by Idaho Fish and Game Department, mimeo. 9 pp. 1953.

Describes a scalping treatment to eliminate competition from annuals and evaluation of browse and grass species for revegetation.

HOLMGREN, RALPH C. Artificial browse revegetation on the Payette big-game winter range. IN: Is artificial feeding of big game animals good management? pp. 22-24, Supplement to Idaho Wildlife Review, March-April 1953.

Review of useful browse species and methods to use in seeding bitterbrush.

ISRAELSON, MARGUERITE A. Publications of the Intermountain Forest and Range Experiment Station, 1912-1950. Research Paper 29, 45 pp. (1952).

Lists publications based on research studies of the Station over a 40-year period.

LAMMI, J. O. Statistical tables on western wild land resources. Research Paper 31, 14 pp. 1953.

Tabulations compiled from various sources, list by each of the 11 western states and also by the portions of these states within the Intermountain region of the U. S. Forest Service, information on the following resources: water, timber, recreation, wildlife, livestock forage, land, and human population.

MARSTON, R. B. Guide to Davis County Experimental Watershed, Farmington, Utah. Intermountain Forest and Range Experiment Station, Ogden, Utah. Mimeo. 19 pp. 1953.

Describes the history of the Davis County Experimental Watershed and features of interest that can be seen on a tour of the area.

TACKLE, DAVID. Lodgepole pine management in the Intermountain region--a problem analysis. Intermountain Forest and Range Experiment Station, Ogden, Utah. (MS.) 70 pp., illus. 1953.

A comprehensive analysis of the problems inherent to the management of lodgepole pine forests in the Intermountain region. Presents a preliminary classification of lodgepole stands supplemented by photographs and descriptions to aid in recognizing them in the field. Includes a list of suggested studies for a research program.

TACKLE, DAVID, and D. I. CROSSLEY. Lodgepole pine bibliography. Research Paper 30, 57 pp. 1953.

A list of 442 references on lodgepole pine. References are listed alphabetically by author and are indexed by number according to subject matter.

WILSON, ALVIN L. Storage and germination of Douglas-fir seed in central Idaho. Research Note 5, 3 pp. 1953.

Germination tests were run on seed collected in 1937 and 1950. None of the 1937 seed germinated, but stratified 1950 seed showed a viability of about 77 percent in 20 days in one test and 72 percent in 30 days in another. Stratified 1950 seed showed 77 percent germination capacity; unstratified seed 54 percent.

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R-INT
REPORTS
Station's Annual

March 23, 1953

Dear Sir:

Enclosed is a copy of the 1952 Annual Report of this Station. This report, you will note, reappraises several of the studies which have been under way for a number of years. The national economic changes have brought about new or increased demands for the resources and services of the wild lands, thus necessitating an occasional shift of emphasis or direction of research.

The report also highlights research activities of the Station, some of which were begun in 1911 at the Great Basin Branch Station. I hope you will find this report of interest, and we will welcome any suggestions or comments you may have.

Sincerely yours,

REED W. BAILEY, Director

By George W. Craddock

Enclosure